

Introduzione alla Realtà Virtuale Parte II

Alberto Borghese



1/78

<http://homes.dsi.unimi.it/~borghese/>



Sommario



- Introduzione
- Sistemi di Input
- **Generatori di mondi**
- Motore di calcolo
- Sistemi di Output
- Conclusioni

A.A. 2006-2007

2/78

<http://homes.dsi.unimi.it/~borghese/>



World generators



Integrated systems for 3D CAD and Animation:

- Maya (ex-Alias/Wavefront)
- XSI (ex-Softimage)
- 3D Studio Max.

- 3D Structure.
- Colour and Texture
- Motion (animation)
- Rendering (lights, shadows)

Camera tracking, transparencies....

Specific CAD for mechanics: Katia, AutoCAD, Nastran SW....



3D structure



Solid modeling

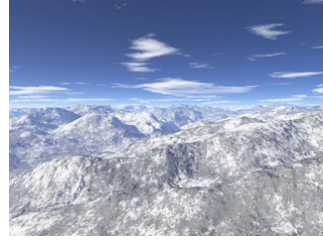
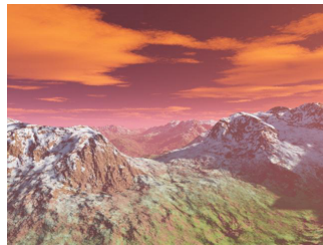
- 3D geometric solids: cubes, cylinders, cones...
- Superquadrics (Terzopoulos and Metaxas, 1991): global parameters + local parameters.
- Revolution surfaces.
- Spline and NURBS (Piegle, 1993). CAD, high interactivity.
- Subdivision surfaces (Schroeder, 1999).

Finite element models

- It is a class per sé. Local modeling. Mechanical modeling.
- Largely used for animation in medicine (facial animation, deformation of tissue during surgery). Multi-layer modeling.



SW Specifico per modellazione terreni (Terragen)



A.A. 2006-2007

5/78

<http://homes.dsi.unimi.it/~borghese/>



3D Scanner: Autoscan - 1997



- Scansione manuale attraverso puntatore laser.
- Guida alla scansione dal feed-back su monitor.
- Flessibilità nel set-up e portabilità.
- Acquisizione spot laser in tempo reale a 100 Hz. (max 100 punti /sec)
La triangolazione diretta dei punti pone dei problemi per la presenza di rumore.

A.A. 2006-2007

6/78

<http://homes.dsi.unimi.it/~borghese/>



Models from range data



Cyberware whole body scanner, WB4



A.A. 2006-2007

7/78

<http://homes.dsi.unimi.it/~borghese/>



Models from range data (II)



Cyberware smaller model
3030



A.A. 2006-2007

8/78

<http://homes.dsi.unimi.it/~borghese/>



3D structure from range data (III)



Polhemus hand held laser scanner

A.A. 2006-2007

9/78

<http://homes.dsi.unimi.it/~borghese/>



Effect of measurement noise is clear with Delaunay triangulation



Need of filtering is evident.

A.A. 2006-2007

10/78

<http://homes.dsi.unimi.it/~borghese/>



Models from range data (IV)



Digibot II.

- Platform rotates
- Scanner line translates.



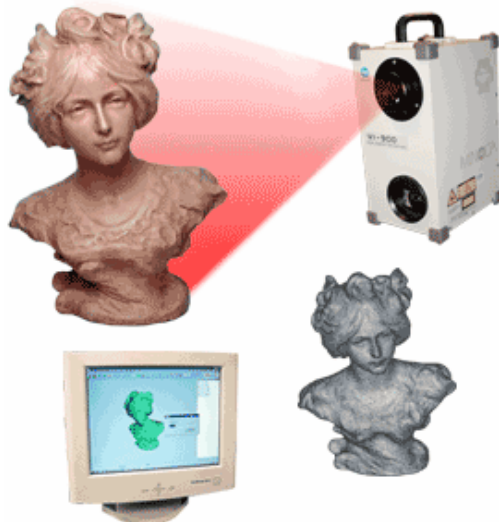
A.A. 2006-2007

11/78

<http://homes.dsi.unimi.it/~borghese/>



MINOLTA
Scanner Laser 3d



Minolta scanner 3D

http://kmpi.konicaminolta.us/eprise/main/kmpi/content/ISD/ISD_Category_Pages/3dscanners

A.A. 2006-2007

12/78

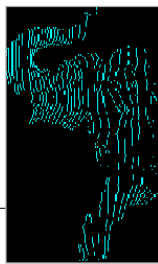
<http://homes.dsi.unimi.it/~borghese/>

Video-based 3D scanner (Rusinkiewicz et al., 2002)

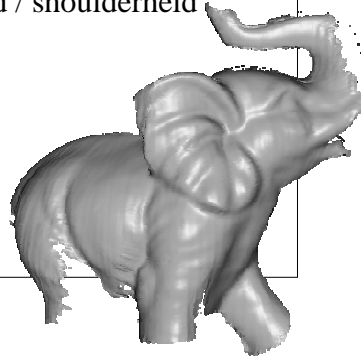
- A projector of stripes with pseudo-random width and a video camera
- holes can be found and filled on-the-fly
- object or scanner can be handheld / shoulderheld



video frame



range data



merged model
(159 frames)

A.A. 2006-2007

13/78

<http://homes.dsi.unimi.it/~borghese/>



3D structure from points



Linear approximation (mesh):

- Delauney triangulation (Watson, 1981; Fang and Piegl, 1992). Direct tessellation (no filtering).
- Alpha shapes, Ball Pivoting (Bernardini et al., 2000), Power Crust (Amenta, 2002). Post processing to regularize a Delauney tessellation.

Surface fitting to range data

- Snakes (Kass et al., 1988). Energy based approach. Best curves.
- Kohonen maps (1990).
- Radial Basis Functions Networks (Poggio and Girosi, 1995; Ferrari et al. 2005, semi-parametric models).

.....

A.A. 2006-2007

14/78

<http://homes.dsi.unimi.it/~borghese/>



Superellissoidi

$$p(\eta, \vartheta) = \begin{bmatrix} a_1 \cos^{\varepsilon_1} \eta \cos^{\varepsilon_2} \theta \\ a_2 \cos^{\varepsilon_1} \eta \sin^{\varepsilon_2} \theta \\ a_3 \sin^{\varepsilon_1} \eta \end{bmatrix}$$

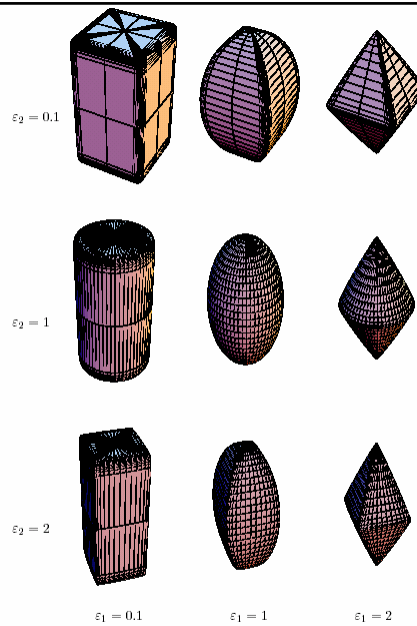
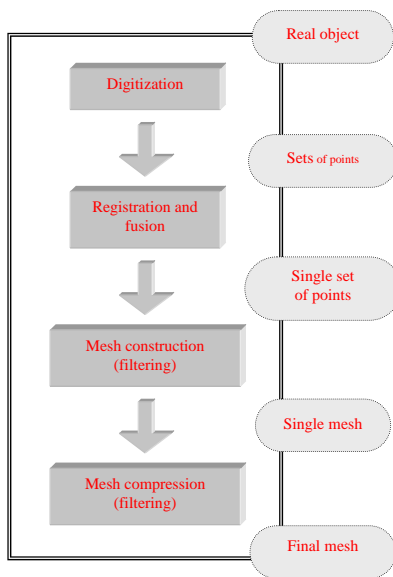


Figure 2.5. Superellipsoids with different values of exponents ε_1 and ε_2 . Size parameters a_1, a_2, a_3 are kept constant. Superquadric-centered coordinate axis z points upwards!



Scanner 3D modern pipeline



M. Levoy, S. Rusinkiewicz, M. Ginzton, J. Ginsberg, K. Pulli, D. Koller, S. Anderson, J. Shade, B. Curless, L. Pereira, J. Davis and D. Fulk, "The Digital Michelangelo Project: 3D Scanning of Large Statues," *Proc. Siggraph'99*, ACM Press, pp. 121-132, 1999



Research challenges



- | | |
|--|--|
| <ul style="list-style-type: none">• vision problems<ul style="list-style-type: none">– aligning and merging scans– automatic hole filling– inverse color rendering– automated view planning | <ul style="list-style-type: none">• digital archiving problems<ul style="list-style-type: none">– making the data last forever– robust 3D digital watermarking– indexing and searching 3D data– real-time viewing on low-cost PCs |
|--|--|

A.A.



Sommario



- Introduzione
- Sistemi di Input
- Generatori di mondi
- **Motore di calcolo**
- Sistemi di Output
- Conclusioni

A.A. 2006-2007

18/78

<http://homes.dsi.unimi.it/~borghese/>



Graphical representation



Graphical engines represent triangles => Every shape is transformed into triangles.

- The models created by the scanners are ensembles of triangles (millions of).
- Much more than required by applications.



Mesh compression. Representation of the same geometry/pictorial attributes, with a reduced set of triangles.

A.A. 2006-2007

19/78

<http://homes.dsi.unimi.it/~borghese/>



Colors **(examples)**

	White	(R=255, G=255, B=255)
	Grey	(R=200, G=200, B=200)
	Dark grey	(R=200, G=200, B=200)
	Black	(R=0, G=0, B=0)
	Red	(R=255, G=0, B=0)
	Yellow	(R=255, G=255, B=0)
	Pale blue	(R=0, G=255, B=255)
	Green	(R=0, G=200, B=0)

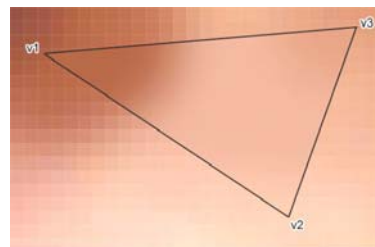
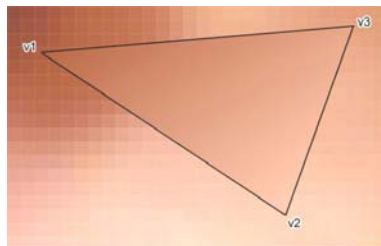
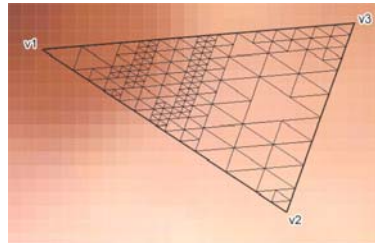
A.A. 2006-2007



Colour models



- Texture mapping. Correspondence between vertexes and points on images. Pixellization. Details inside a triangle.
- Colour per vertexes. The colour of the vertexes is sampled on the image. Continuous field.



VRML format



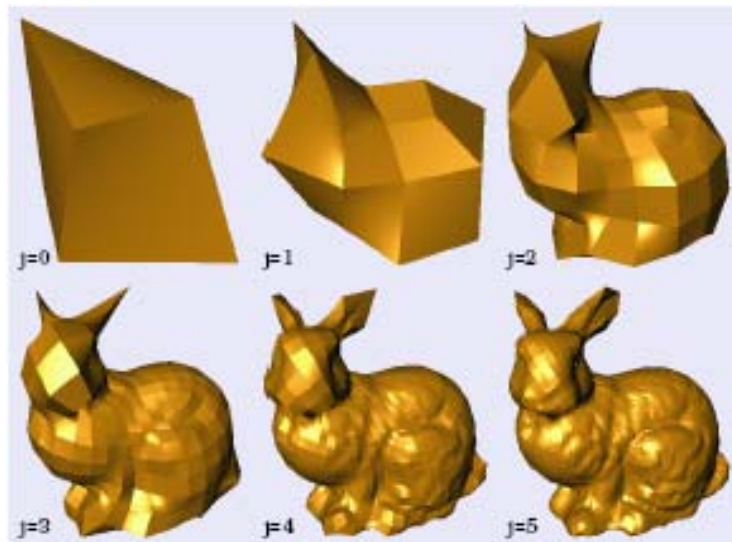
```

#VRML V2.0 utf8
Viewpoint {
  position 0 0 3
  orientation 0 0 1 0
  fieldOfView 0
}
DirectionalLight {
  intensity 0.2
  ambientIntensity 0.2
  color 0.9 0.9 0.9
  direction 0 -1 -1
}
Group {
  children Group {
    children [
      Transform {
        children Shape {
          appearance Appearance {
            material Material {
              ambientIntensity 1
              diffuseColor 0.9 0.9 0.9
              specularColor 0 0 0
              emissiveColor 0 0 0
              shininess 0
              transparency 0
            }
          }
        }
      ]
    ]
  }
  geometry IndexedFaceSet {
    coord Coordinate {
      point [
        -30.180237 -231.844711 -101.136322,
        -9.759983 -198.816086 -112.282883,
        ...
        41.981602 -72.366501 -38.740982,
        33.281391 -76.643936 -48.074211,
      ]
    }
    color Color {
      color [
        0.9 0.9 0.9,
        0.9 0.9 0.9,
        ...
        0.9 0.9 0.9,
        0.9 0.9 0.9,
      ]
    }
    coordIndex [
      10, 685, 970, -1,
      0, 1133, 1162, -1,
      ...
      263, 472, 1176, -1,
      263, 666, 1176, -1,
    ]
  }
  colorPerVertex TRUE
  cew TRUE
  solid TRUE
  creaseAngle 8
  translation 0 0 0
  center 0 0 0
  scale 1 1 1
}

```



LOD models



A.A. 2006-2007

23/78

<http://homes.dsi.unimi.it/~borghese/>



The graphical engine (visual computing)



Double buffering (for real-time visualization of 3D models) + rasterization.

Hardware acceleration of graphical operations (OpenGL, texture mapping...). GPU.

Interpolation of normals direction among adjacent triangles.

GPU programming language (cf. nVidia).

Graphical pipelining (geometry, colour, texture, shadowing, rendering...).

Parallelization.

Multiple cache levels.

Look-ahead code optimization (compiler optimization).

A.A. 2006-2007

24/78

<http://homes.dsi.unimi.it/~borghese/>



Collision detection



Computational demanding ($O(n^2EF)$).

Use of multiresolution models.

Hierarchical detection.

- Geometry simplification (axes aligned faces).

- Check for common volumes.

- Extraction of the faces belonging to these volumes.

- Ocree of the pairs of candidate faces.

- Check for intersection.



Collision detection at work





Sommario



- Introduzione
- Sistemi di Input
- Generatori di mondi
- Motore di calcolo
- **Sistemi di Output**
- Conclusioni



Sistemi di Output::display aptici





Haptic displays



Convey to the subject the sensorial information generated in the interaction with the virtual objects: force, material texture...

Measure the force exerted by the subject on the virtual environment.

Haptic displays provide a mechanical interface for Virtual Reality applications.

Most important developments have been made in the robotics field.

International Haptic society - <http://www.isfh.org/>



Cyber grasp



Cyber Grasp:

- max 12 N per dito
- Peso 350 grammi





Requirements of Haptic displays



- Large bandwidth.
- Low inertial and viscosity.


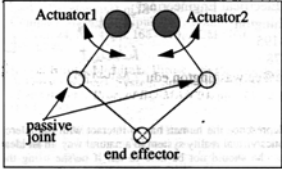
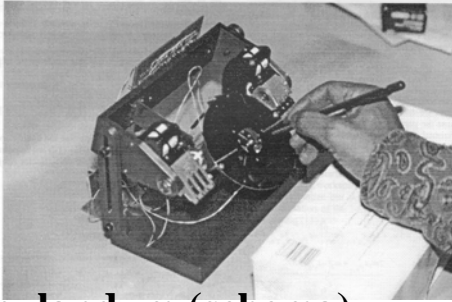
Technological solutions (oggetto intermediario):

- Direct drive manipulandum (Yoshikawa, 1990), Phantom (2000).
- Parallel manipulandum (Millman and Colgate, 1991; Buttolo and Hannaford, 1995).
- Magnetic levitation devices (Salcudean and Yan, 1994; Gomi and Kawato, 1996).
- Gloves (Bergamasco, 1993).

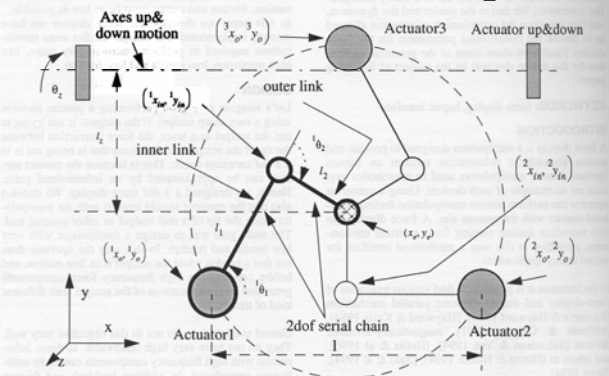


Direct drive manipulandum (phantom)





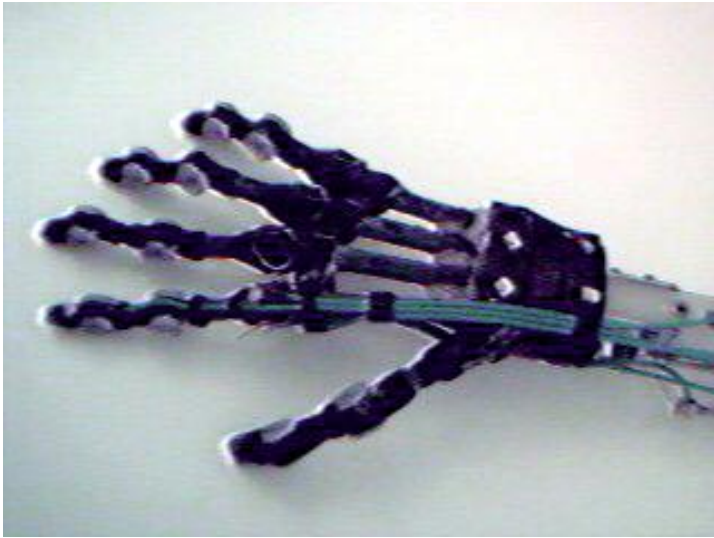
Parallel manipulandum (schema)



<http://homes.dsi.unimi.it/~borghese/>



Gloves (Blackfinger, 2000)

A.A. 2006-2007 34/78 <http://homes.dsi.unimi.it/~borghese/>



Percro gloves (2002)



Sensori goniometrici – non devono essere calibrati sulla lunghezza delle falangi.

<http://www.percro.org>

A.A. 2006-2007

35/78

<http://homes.dsi.unimi.it/~borghese/>

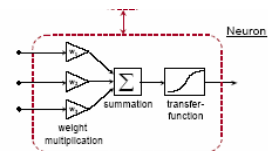


Other output devices



Audio – Stereo, sound spatialization.

Olfactory – Virtual nose



Type	Sensitive material	Detection principle
semiconducting metal oxides (M.O.S., Taguchi)	doped semiconducting metal oxides (SnO ₂ , GaO)	resistance change
quartz crystal microbalance, QMB surface acoustic wave, SAW	organic or inorganic layers (gas chromatography)	frequency change due to mass change
conducting polymers	modified conducting polymers	resistance change
catalytic field-effect sensors (MOSFET)	catalytic metals	workfunction change
pellistor	catalysts	temperature change due to chemical reactions
fluorescence sensors	organic dyes	light intensity changes
electrochemical cells	solid or liquid electrolytes	current or voltage change
infr red sensors	-	IR absorption

A.A. 2006-2007

36/78

<http://homes.dsi.unimi.it/~borghese/>



Stimolatori tattili



Cyber touch:

- 6 vibratori, uno per dito più 1 sul palmo
- Frequenza di vibrazione: 0-125 Hz.
- Ampiezza di vibrazione: 1.2 N @ 125 Hz (max).

Iwamoto & Shinoda

University of Tokio



A.A. 2006-2007

37/78

<http://homes.dsi.unimi.it/~borghese/>



Sistemi di Output::display



A.A. 2006-2007

38/78

<http://homes.dsi.unimi.it/~borghese/>



Optical Output systems



Requirements for the monitor:

- Large field of view ($180^\circ \times 150^\circ$).
- High spatial resolution (35 pixels/degree, equivalent to 12,000x12,000 pixels for a 19" display positioned at 70cm from the viewer).

Requirements for the world generator:

- Stereoscopic vision for objects with $D < 10m$.
- Monocular cues for objects with $D > 10m$.
 - - Occlusions.
 - - Geometrical perspective and a-priori model knowledge.
 - - Shading.
 - - Motion.

A.A. 2006-2007

39/78

<http://homes.dsi.unimi.it/~borghese/>



La camera come strumento di ripresa



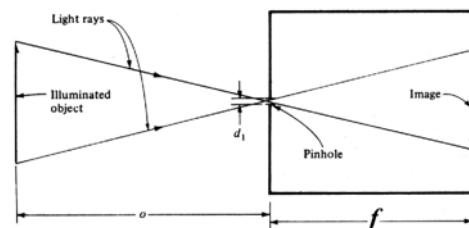
Come si forma un'immagine?

- Scena con oggetti riflettenti.
- Sorgente di illuminazione
- Piano di rilevazione della luce riflessa.



Modello pin-hole

Il motore di questa trasformazione è la **proiezione prospettica**.



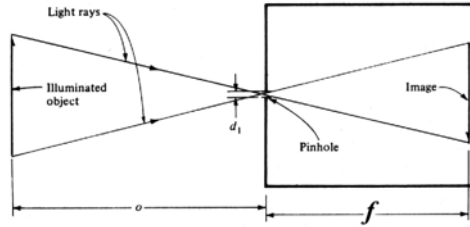
A.A. 2006-2007

40/78

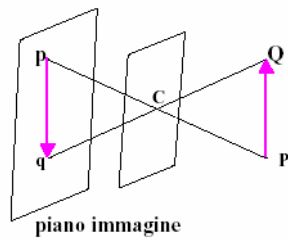
<http://homes.dsi.unimi.it/~borghese/>



La pin-hole camera



Proiezione prospettica:
tutti i raggi di proiezione
passano per un unico punto,
detto **centro di proiezione**.



Pinhole camera

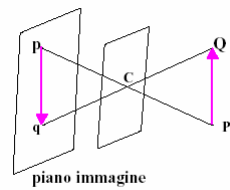
A.A. 2006-2007

41/78

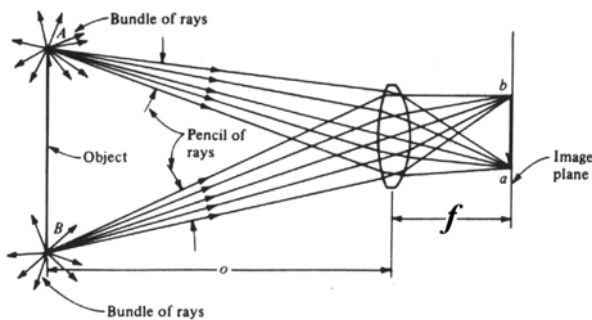
<http://homes.dsi.unimi.it/~borgnese/>



La lente



Pinhole camera



Lente convergente

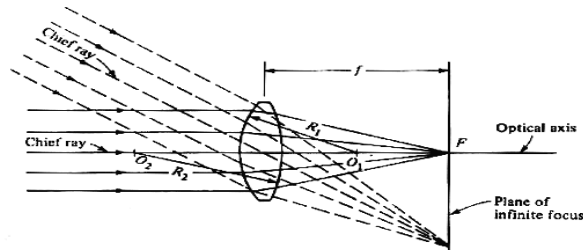
A.A. 2006-2007

42/78

<http://homes.dsi.unimi.it/~borgnese/>



Geometria dell'ottica



Oggetti all'infinito

- **Distanza focale**: distanza del piano immagine quando un oggetto si trova all'infinito.
- **Asse ottico**: raggio che non viene deviato dalla lente.
- **Intersezione dell'asse ottico con il piano immagine dà il punto principale (F).**

A.A. 2006-2007

43/78

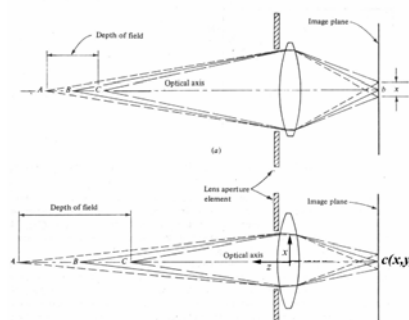
<http://homes.dsi.unimi.it/~borghese/>



Messa a fuoco



Problema della messa a fuoco



Parametri di camera (o intrinseci):

- **Punto principale $c(x,y)$ + lunghezza focale, f (3 parametri).**
- **Occorre conoscere anche il fattore di forma dei pixel nel caso di immagini digitali (è una costante, non un parametro).**
- **(Distorsioni).**

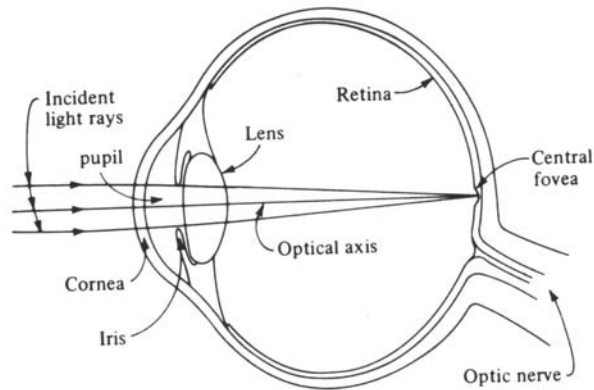
A.A. 2006-2007

44/78

<http://homes.dsi.unimi.it/~borghese/>



L'occhio umano



Its behavior is very similar to that of a camera

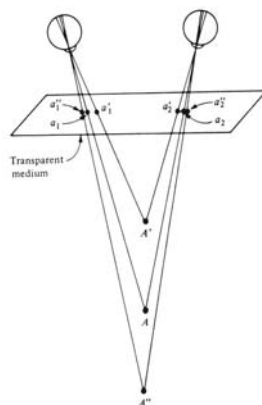
A.A. 2006-2007

45/78

<http://homes.dsi.unimi.it/~borghese/>



Stereo-disparity



Points further away are projected on points closer to the image center.

Vergence and focusing are strictly connected.

Also monocular cues: shading, apparent size,

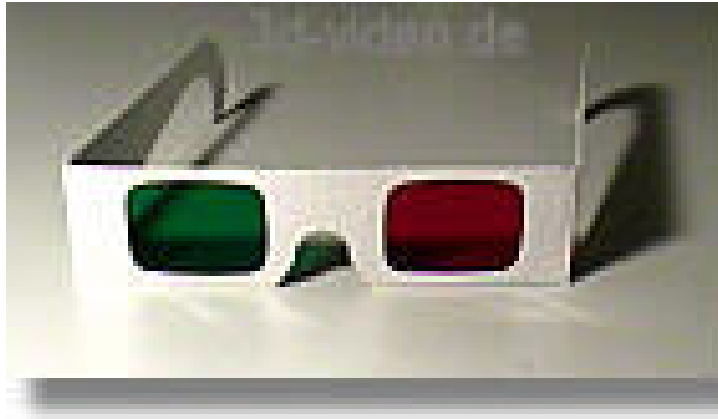
A.A. 2006-2007

46/78

<http://homes.dsi.unimi.it/~borghese/>



Passive stereo



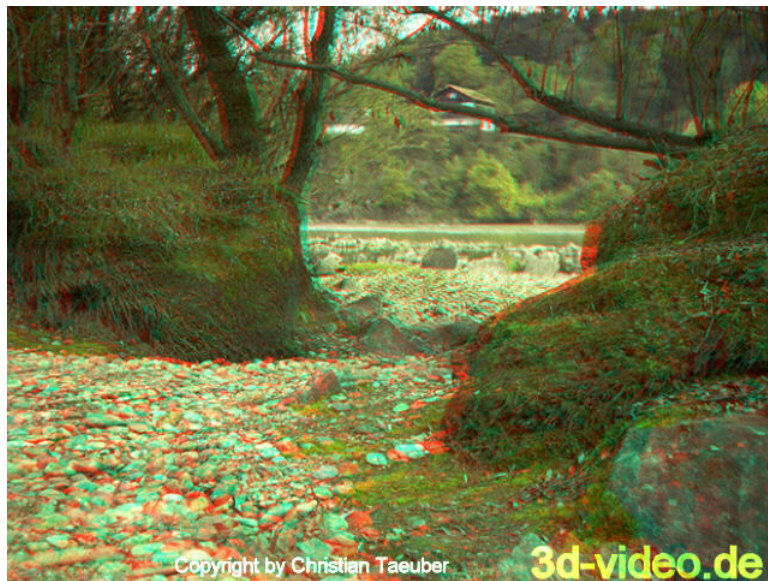
A.A. 2006-2007

47/78

<http://homes.dsi.unimi.it/~borghese/>



Stereo image for passive stereo



A.A. 2006-2007

48/78

<http://homes.dsi.unimi.it/~borghese/>



Stereogramma con parallasse



Brevetto del 1903

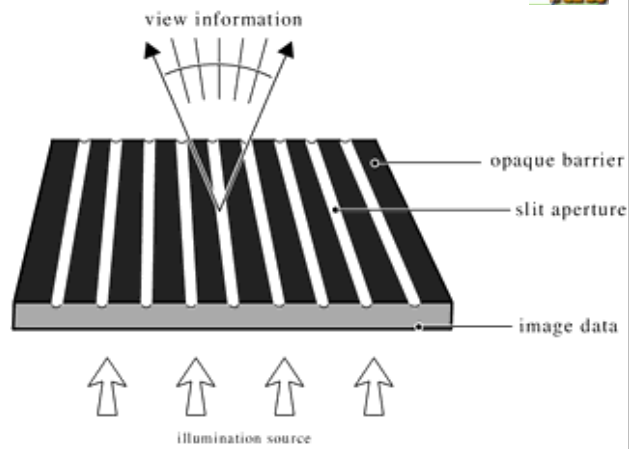


Immagine suddivisa in strisce verticali.

Coppie di strisce, associate alla parallasse orizzontale, sono posizionate in funzione dell'angolo.

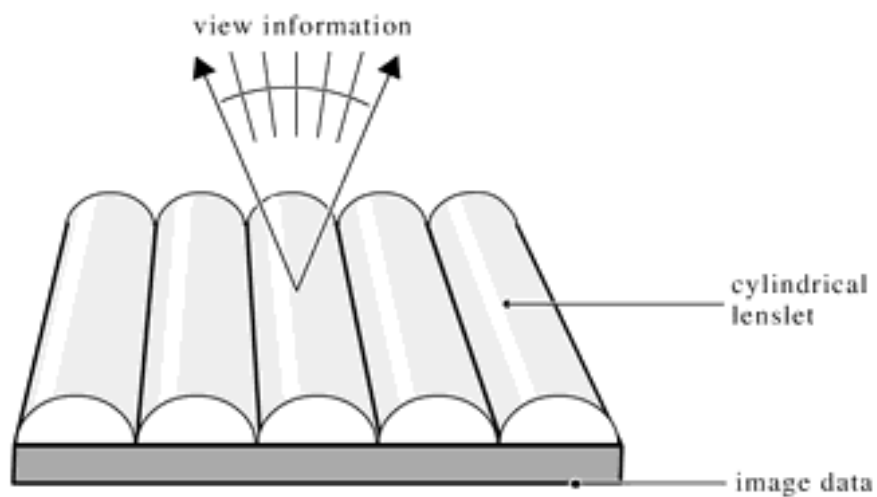
A.A. 2006-2007

49/78

<http://homes.dsi.unimi.it/~borghese/>



Display Autostereoscopici



A.A. 2006-2007

50/78

<http://homes.dsi.unimi.it/~borghese/>



Output devices (eye-glasses)



Semi-immersive: Eye-glasses (video accuracy, but user is not allowed to move, lateral vision is permitted, which limits virtual realism).



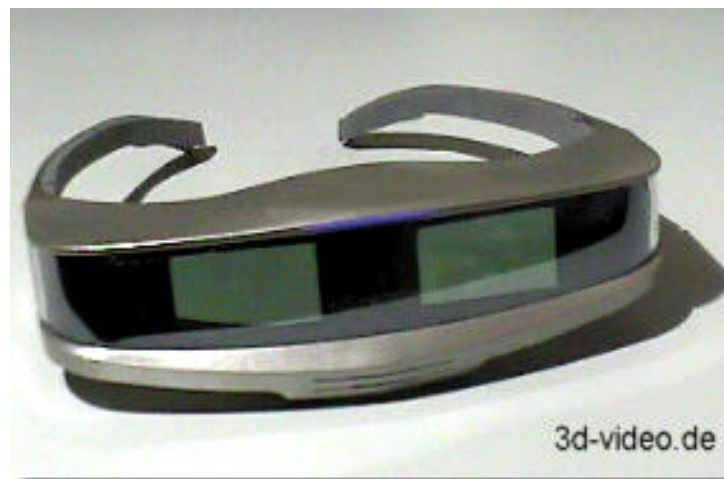
A.A. 2006-2007

51/78

<http://homes.dsi.unimi.it/~borghese/>



I-glasses (games)



A.A. 2006-2007

52/78

<http://homes.dsi.unimi.it/~borghese/>



HMD (n-vision)



Up to 1280 x 1024, 180Hz.
Time multiplexing.

A.A. 2006-2007

53/78

<http://homes.dsi.unimi.it/~borghese/>



Output devices (BOOM HMD)



Up to 1280 x 1024 pixels / eye
CRT Technology
Head tracking is integrated.



A.A. 2006-2007

54/78

<http://homes.dsi.unimi.it/~borghese/>

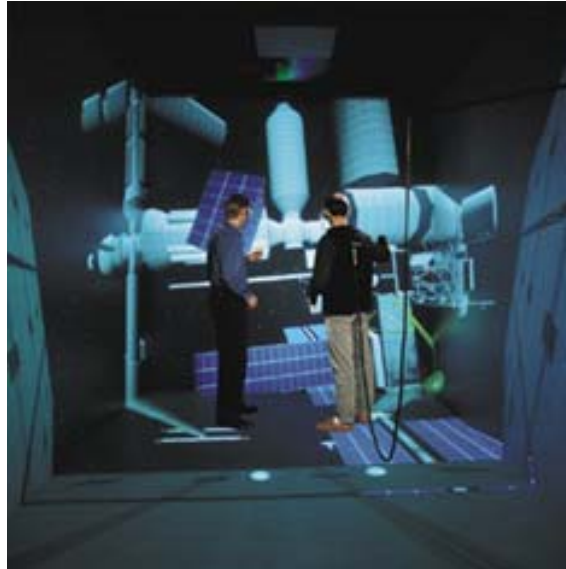


CAVE



Room 2.5m x 2.5m
with Virtual images
(stereoscopic) projected
onto its walls.

More people and
Complete immersivity.



A.A. 2006-2007

55/78

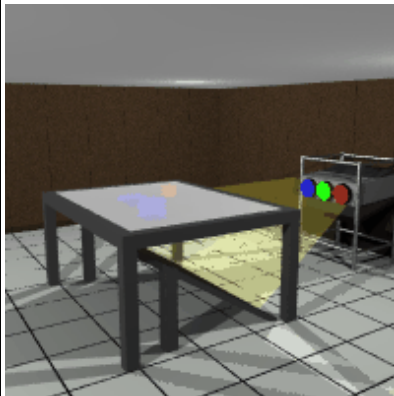
<http://homes.dsi.unimi.it/~borghese/>



Responsive work-bench (Strauss et al., 1995)



Virtual 3D objects are positioned on a working table. They are
created projecting the stereo images over the table surface.



A.A. 2006-2007

56/78

<http://homes.dsi.unimi.it/~borghese/>



Large screen displays



Workwall



A.A. 2006-2007

57/78

<http://homes.dsi.unimi.it/~borghese/>



Physiological problems





- SIMM and VR sickness limit the exposure time.
- Size and distances misperception.
- Limited range in extrapersonal space.


A.A. 2006-2007

58/78


<http://homes.dsi.unimi.it/~borghese/>

Wearable devices - Orologi








Computer palmare



Wrist-net
N3





Xelibri – Orologio/telefonino
(come digitare un numero?)




“Paparazzi”

A.A. 2006-2007 59/78 http://homes.d:

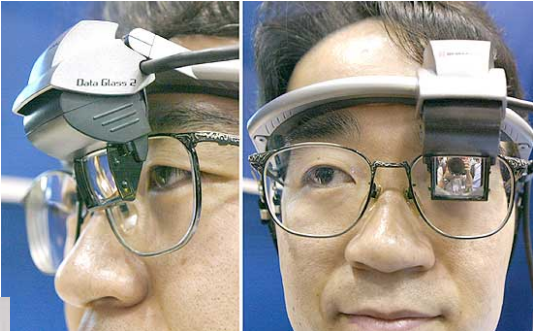
Wearable devices – input / output

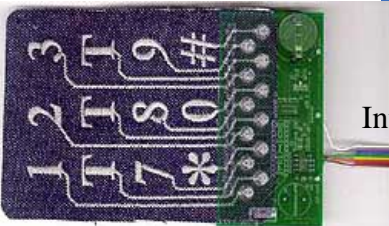





HMD – 320x240 VGA

Characteristics: mobile, context sensitive, augmented reality.





Interfaccia su stoffa.

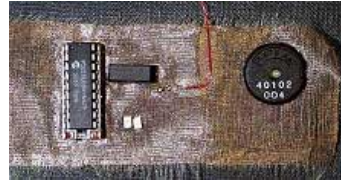
60/78 http://homes.dsi.unimi.it/~borghese\



Wearable devices – Da indossare



E-textile



Circuito stampato su stoffa



Ciondolo
contenente
dati
personali



Siemens
penna-telefono

A.A. 2006-2007

61/78

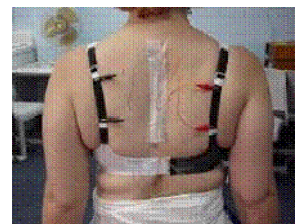
<http://homes.dsi.unimi.it/~borghese/>



Wearable devices - IV



Electronical cloths - Sony



Smart cloths

MIT Media lab and industrial style.

A.A. 2006-2007

62/78

<http://homes.dsi.unimi.it/~borghese/>



Wearable devices – Micro-sensors



MEMS devices

Typically a MEMS accelerometer consists of interlocking fingers that are alternately moving and fixed. Acceleration is sensed by measuring the capacitance of the structure, which varies in proportion to changes in acceleration.

The elements can be arranged like combs to make a linear accelerometer, as is the type used in airbags, or like the spokes of a wheel to make a rotational accelerometer.

A.A. 2006-2007

63/78

<http://homes.dsi.unimi.it/~borghese/>

Prototype3



<http://world.honda.com/ASIMO/P3/>
Investimento di 10 anni e 100 milioni di dollari.

Robotics – fourth generation



Qrio - Sony



Leonardo - MIT

Visione Movimento
Coordinazione, flotta di robot (Wifi 802.11b).



A.A. 2006-2007

64/78



Sommario



- Introduzione
- Sistemi di Input
- Generatori di mondi
- Motore di calcolo
- Sistemi di Output
- **Conclusioni**



Applications



- Army
- Medicine
- Industry (inspection, virtual prototyping)
- Chemistry and Physics
- Virtual theaters and theme parks
- Entertainment
- Communication
- Engineering, Ergonomics and Architecture (Visual computing).
- History.



Indossatrice Virtuale



Cf. Politecnico di Losanna

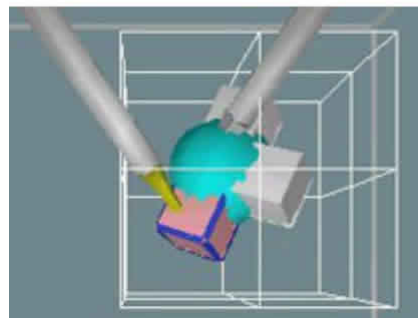
A.A. 2006-2007

67/78

<http://homes.dsi.unimi.it/~borghese/>



Simulazione di interventi di chirurgia mininvasiva



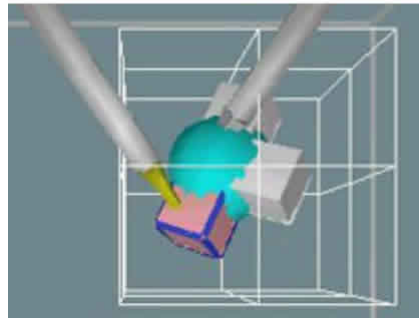
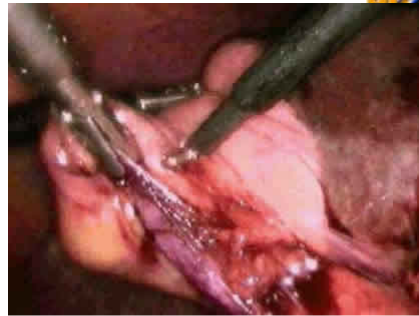
A.A. 2006-2007

68/78

<http://homes.dsi.unimi.it/~borghese/>



Simulazione di interventi di chirurgia mininvasiva



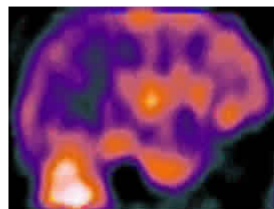
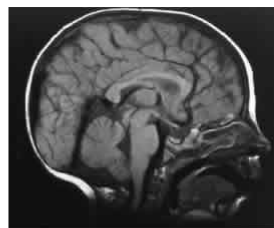
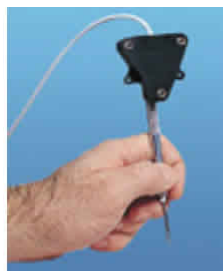
A.A. 2006-2007

69/78

<http://homes.dsi.unimi.it/~borghese/>



Fusione di immagini pre e intra operatorie



A.A. 2006-2007

70/78

<http://homes.dsi.unimi.it/~borghese/>



Realizzazione di oggetti 3D



Mandibola acrilica realizzata con tecnologia CAD-CAM a partire da scansioni TAC

A.A. 2006-2007

71/78

<http://homes.dsi.unimi.it/~borghese/>



Anatomia virtuale



Location: <http://corbamed.bioing.polimi.it/enet/>

Connection Term search Semantic search **Visual browsing** Constrained query

ll organ
bone
brain
eye
genital organ
gland
kidney, left
kidney, right
pancreas
parotid gland, left
parotid gland, right
prostate
suprarenal gland, le
suprarenal gland, rig
thyroid, left

Image list 10
Slice #579
Slice #580
Slice #581
Slice #582
Slice #583
Slice #584
Slice #585
Slice #586
Slice #587
Slice #588

kidney, left
is-a-kind-of gland
is-part-of urinary system
is-located-in abdomed

A.A. 2006-2007

72/78

<http://homes.dsi.unimi.it/~borghese/>



Progettazione: impianti virtuali



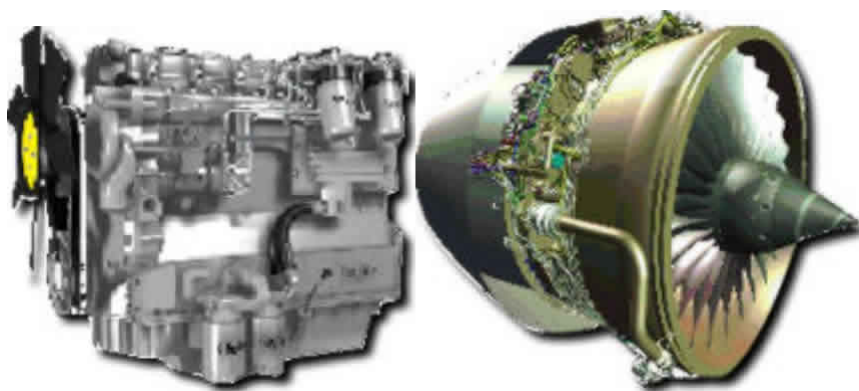
A.A. 2006-2007

73/78

<http://homes.dsi.unimi.it/~borghese/>



Progettazione: motori virtuali



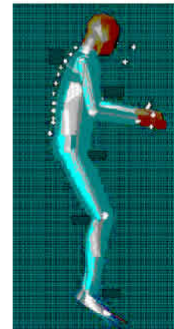
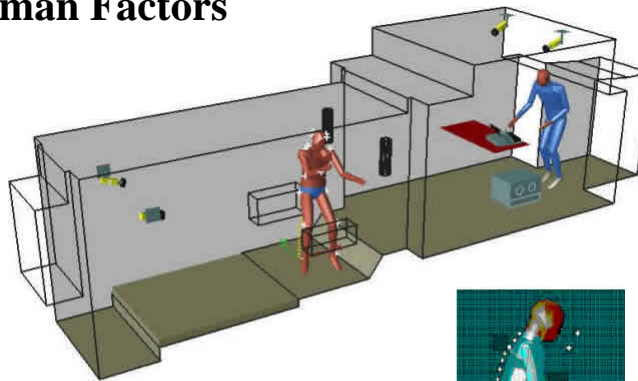
A.A. 2006-2007

74/78

<http://homes.dsi.unimi.it/~borghese/>



Human Factors



A.A. 2006-2007

75/78

<http://homes.dsi.unimi.it/~borghese/>



La città di Giotto



LA CITTA' DI GIOTTO

Visita virtuale alla Basilica di San Francesco

Realizzazione:
Infobyte e CNR per ENEL

A.A. 2006-2007

76/78

<http://homes.dsi.unimi.it/~borghese/>



La tomba di Nefertari



A.A. 2006-2007

77/78

<http://homes.dsi.unimi.it/~borghese/>



Sommario



- Introduzione
- Sistemi di Input
- Generatori di mondi
- Motore di calcolo
- Sistemi di Output
- Conclusioni

A.A. 2006-2007

78/78

<http://homes.dsi.unimi.it/~borghese/>