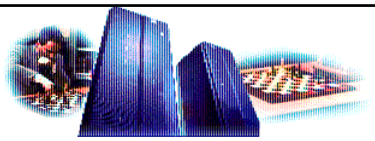
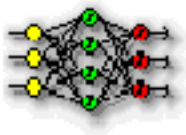




Introduzione alla Realtà Virtuale
Parte II

Alberto Borghese

Sommario

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

World generators

Integrated systems for 3D CAD and Animation:
•Maya (ex-Alias/Wavefront)
•3D Studio Max.

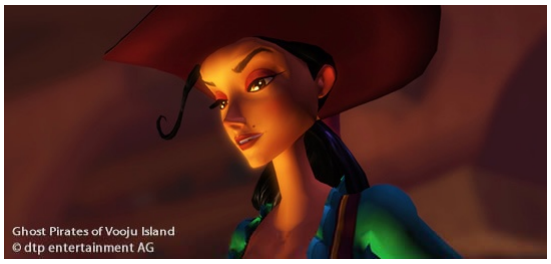
OpenSource systems for graphics
•Ogre3D

Open Source Game Engines
•**Panda3D**, Unity

….

Panda3D - http://www.panda3d.org/

Panda3D is a game engine, a framework for 3D rendering and game development for Python and C++ programs. Panda3D is Open Source and free for any purpose, including commercial ventures, thanks to its liberal license



Managing collisioni detection, animation, accepting input for a wide range of devices (Web-cam and Kinect)

OGRE3D - http://www.ogre3d.org/

Dynastica web browser gameplay trailer.flv

Comparison

Comparison OGRE3D – Panda3D	OGRE3D	Panda3D
Type	3D rendering engine	3D game engine
Language(s)	C++	C++, Python
Bindings	Python, java	
License	MIT License	BSD license
Free for commercial application	Yes	Yes
Graphics subsystem	OpenGL and Direct3D support	OpenGL and Direct3D support
OS	Win, Linux, OSX	Win, Linux, OSX
Shader support	Yes	Yes
Audio	Using external libs	Embedded (OpenAL)
Collision detection	Using external libs	Embedded
Physics system	Using external libs	Embedded (ODE)
Keyboard and Mouse support	Using OIS	Embedded
Support for I/O devices	-	Embedded
Finite state machines	-	Embedded
GUI	Using external libs	Embedded
Skeletal animation	Yes	Yes
Particle Systems	Yes	Yes

3D structure

Solid modeling

- 3D geometric solids: cubes, cylinders, cones…
- Revolution surfaces.
- Spline and NURBS (Piegle, 1993). CAD, high interactivity.
- Subdivision surfaces (Schroeder, 1999).
- Hierarchy of objects with heritage.

Rendering

- Colour and Texture
- lights, shadows.

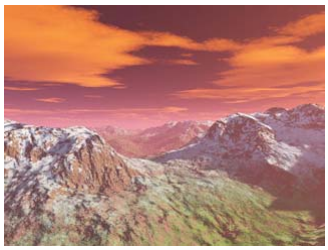
Animation

- Motion (animation)
- Camera tracking (for aumented reality)

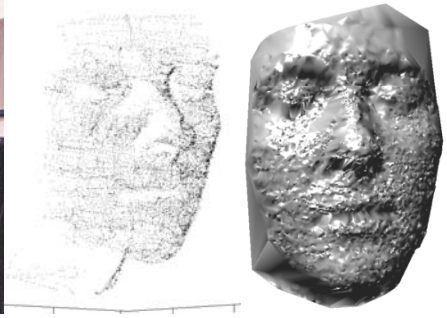
Finite element models

- It is a class per sé. Local modeling. Mechnical modeling.
- Largely used for animation in medicine (facial animation, deformation of tissue during surgery). Multi-layer modeling.
- Specialized SW are usually associated: Katia, AutoCAD...

SW Spefico per modellazione terreni (Terragen, reconstruction of Vajont history)



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.

Models from range data

Cyberware whole body scanner, WB4

Models from range data (II)

Cyberware smaller model 3030

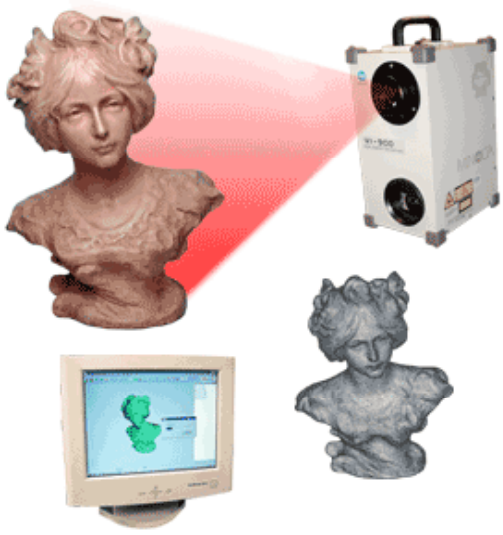
3D structure from range data (III)

Polhemus hand held laser scanner

Models from range data (IV)

Digibot II.
•Platform rotates
•Scanner line translates.

MINOLTA
Scanner Laser 3d

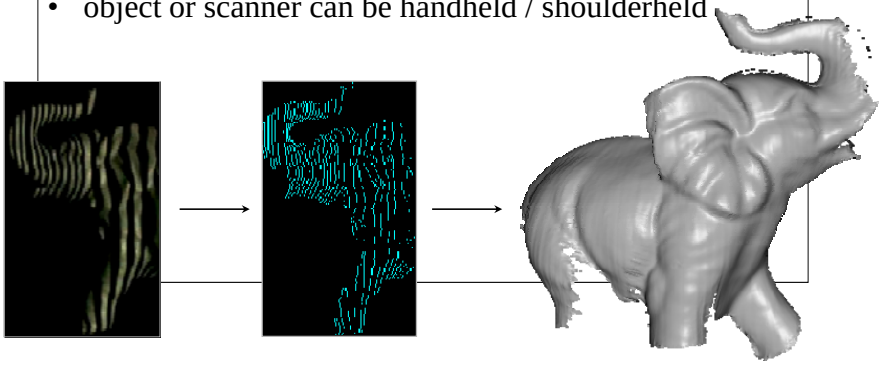


Minolta scanner 3D

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

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)

Effect of measurement noise is clear with Delaunay triangulation

Need of filtering is evident.

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 (median axis transoform, Amenta, 2002). Post processing to regularize a Delauney tessellation.

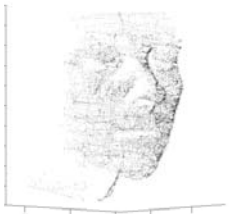
•**Surface fitting to range data**

• Snakes (Kass et al., 1988). Energy based approach. Best curves.

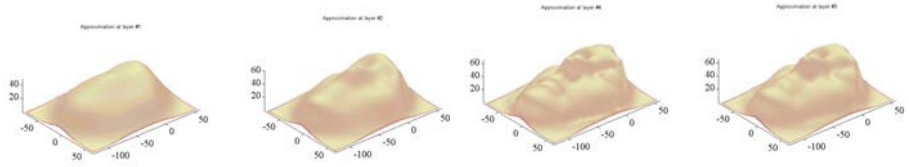
• Kohonen maps (1990).

• Radial Basis Functions Networks (Poggio and Girosi, 1995; Ferrari et al. 2005, semi-parametric models, incremental approach).

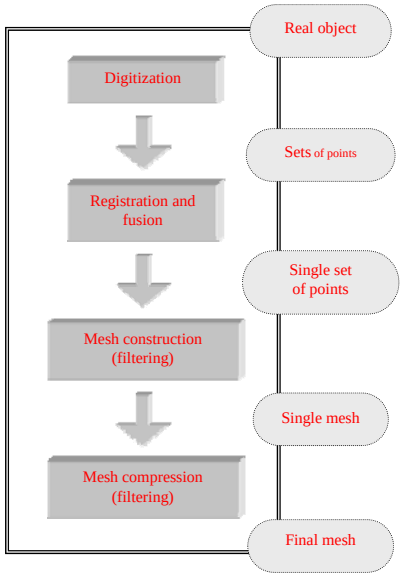
• Support Vector Regression (SVR, A.Smola and B.Scholkopf)



.....



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

- vision problems
  - aligning and merging scans
  - automatic hole filling
  - inverse color rendering
  - automated view planning
- digital archiving problems
  - making the data last forever
  - robust 3D digital watermarking
  - indexing and searching 3D data
  - real-time viewing on low-cost PCs

Sommario

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

Graphical representation

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

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

⇓

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

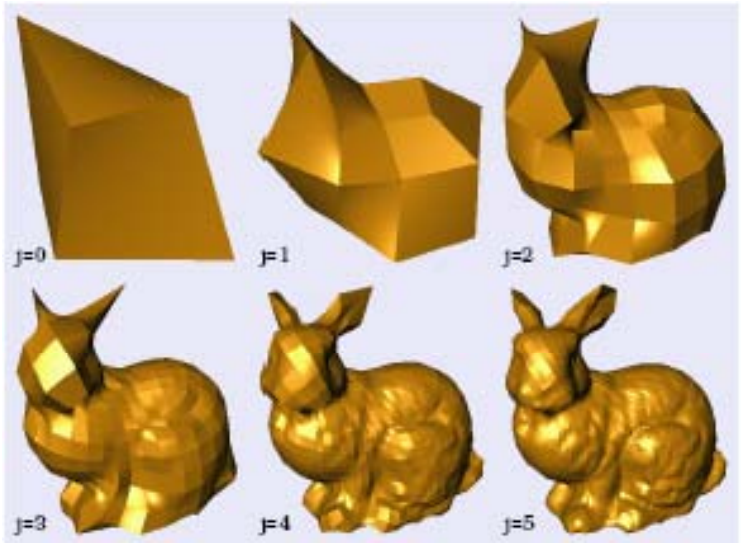
VRML format

```
#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
ccw TRUE
solid TRUE
creaseAngle 8
}
}
translation 0 0 0
center 0 0 0
scale 1 1 1
}
]
}
}
```

LOD models



The graphical engine (visual computing)

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

Interpolation of normals direction among adjacent triangles.

Graphical pipelining (geometry, colour, texture, shadowing, rendering…).
GPU programming language (CUDA nVidia).

Parallelization.

Hierarchy of structures (objects, collision detection...)

Multiple cache levels.

Look-ahead code optimization (compiler optimization).

Collision detection

Computational demanding (On^2EF).
Use of multiresolution models.
Hierarchical detection.
- Geometry semplification (axes aligned faces).
- Check for common volumes.
- Extraction of the faces belonging to these volumes.
- Octree of the pairs of candidate faces.
- Check for intersection.

Sommario

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

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.

Aptic 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/

Requirements of Haptic displays

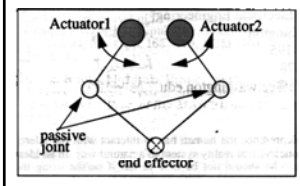
- Large bandwidth.
- Low intertial and viscosity.

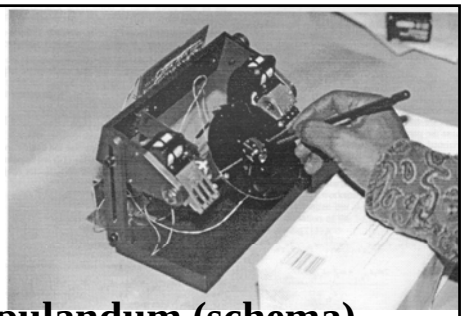
Technological solutions (oggetto intermediario):

- 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 and esoskeleta (Bergamasco, 1993, MITmanus, 2000, Braccio di ferro, 2007).

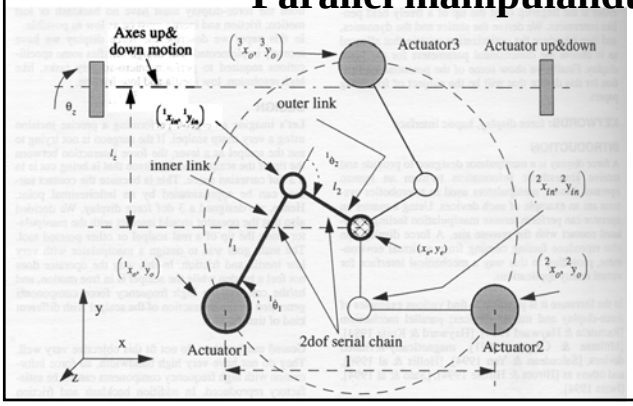
Direct drive manipulandum (phantom)

A similar device (Falcon) si available and used in our lab for rehabilitation

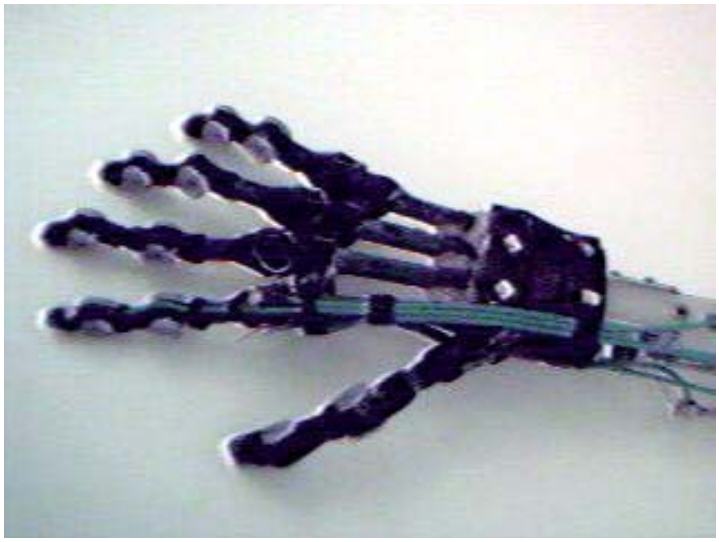




Parallel manipulandum (schema)



Gloves (Blackfinger, 2000)



Percro glove (2002)

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

http://www.percro.org

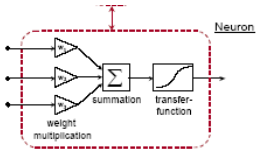
MIT-Manus, 2004

Braccio di ferro, 2010

Support for the fore-arm, and generation of a force field.

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
infra red sensors	-	IR absorption

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

Sistemi di Output::display

Optical Output systems

Requirements for the monitor:

• Large field of view (180º x 150º).

•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.

La camera come strumento di ripresa

Come si forma un'immagine?

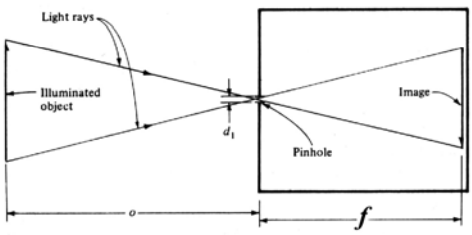
•Scena con oggetti riflettenti.

•Sorgente di illuminazione

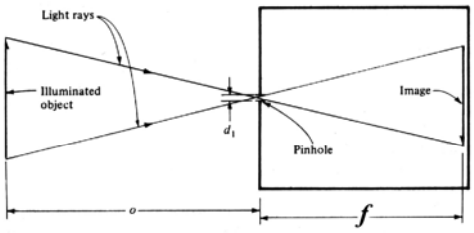
•Piano di rilevazione della luce riflessa.

Modello pin-hole

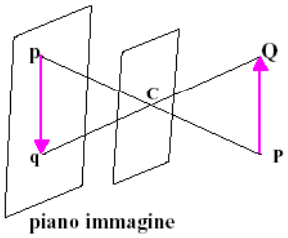
Il motore di questa trasformazione è la **proiezione prospettica**.



La pin-hole camera

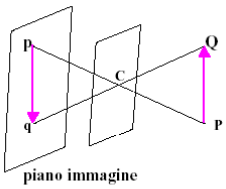


Proiezione prospettica: tutti i raggi di proiezione passano per un unico punto, detto **centro di proiezione**.

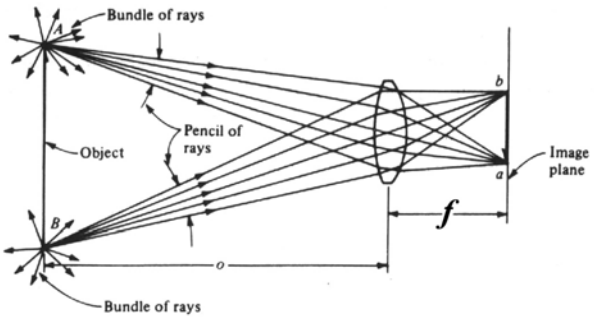


Pinhole camera

La lente

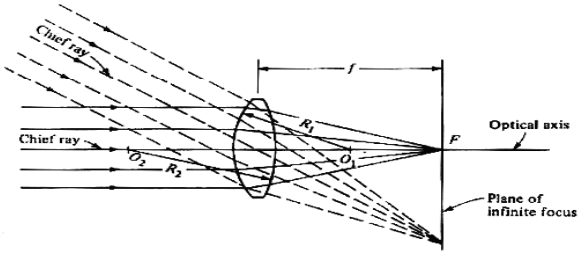


Pinhole camera



Lente convergente

Geometria dell'ottica

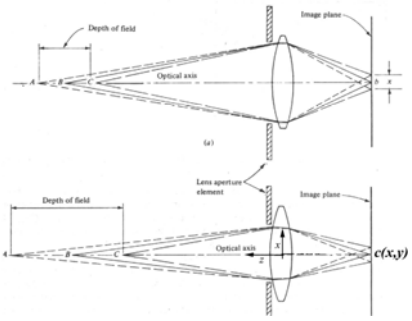


Oggetti all'infinito

•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).

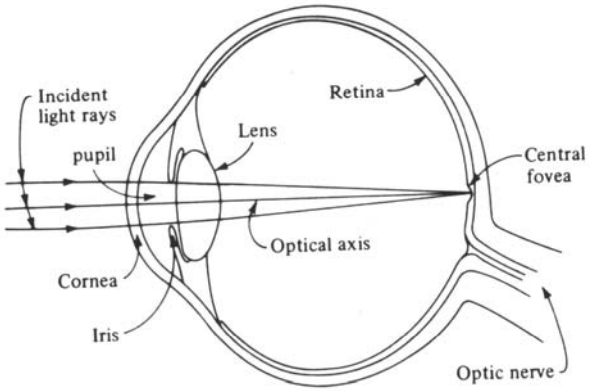
Messa a fuoco

Problema della messa a fuoco



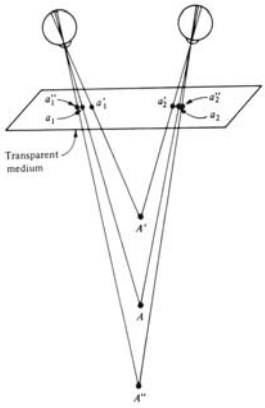
Parametri di camera (o intrinseci):
•Punto principale c(x,y) + lunghezza focale, f (3 parametri).
•Occorre conoscere anche il fattore di forma dei pixel nel caso di immagini digitali (è una costante, non un parametro).
•(Distorsioni).

L'occhio umano



Its behavior is very similar to that of a camera

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, …..

Passive stereo

Stereo image for passive stereo

Stereogramma con parallasse

Brevetto del 1903

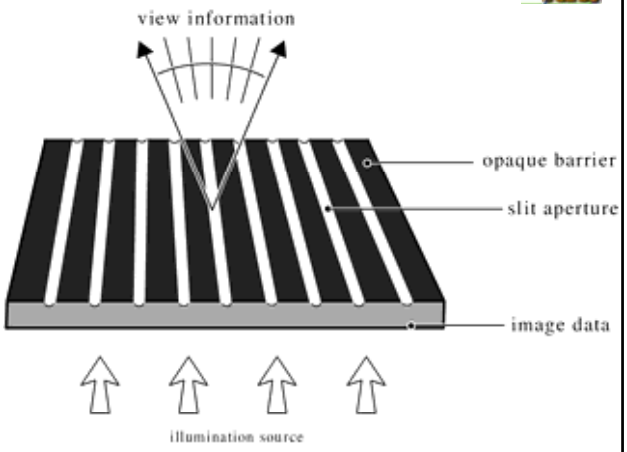
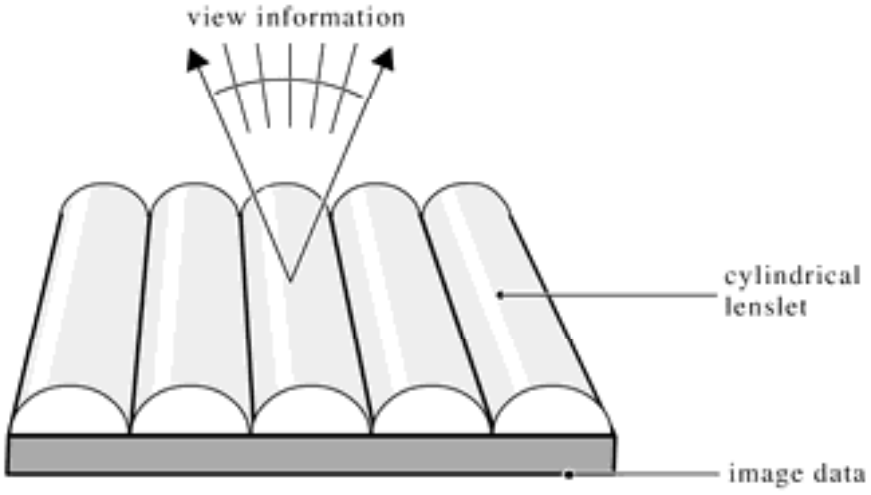


Immagine suddivisa in strisce verticali.

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

Display Autostereoscopici



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).

I-glasses (games)

HMD (n-vision)

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

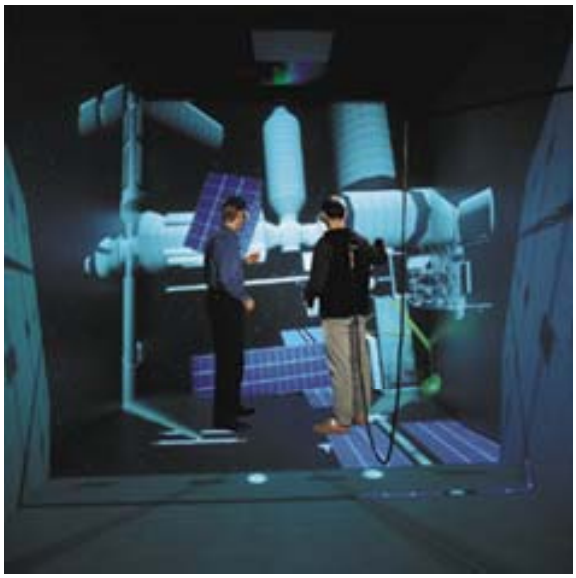
Output devices (BOOM HMD)

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

CAVE

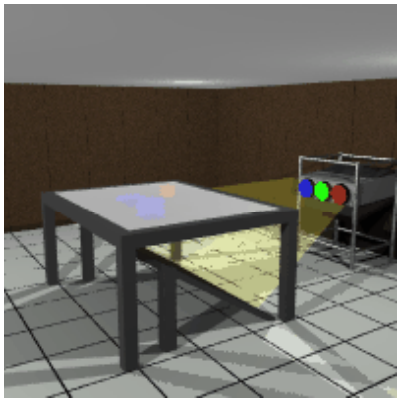
Room 2.5m x 2.5m with Virtual images (steoscopic) projected onto its walls.

More people and Complete immersivity.



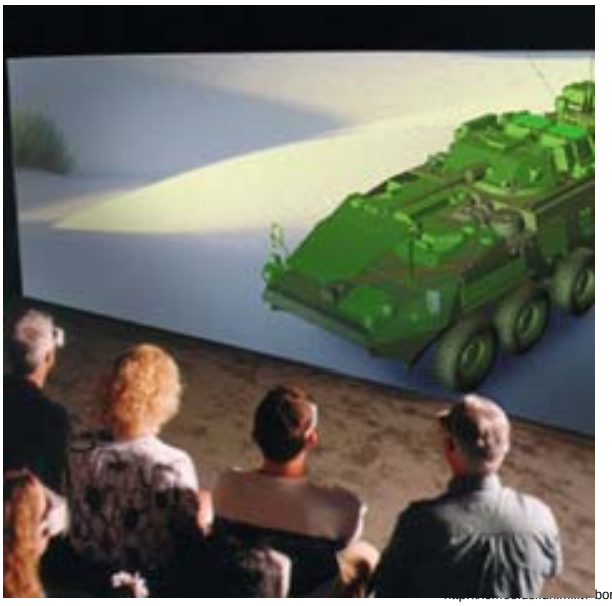
Responsive work-bench (Strauss et al., 1995)

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



Large screen displays (with or without stereo – see Graphics Lab in Celoria)

Workwall



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
- Enterteinment
- Comunication
- Engineering, Ergonomics and Architecture (Visual computing).
- History.

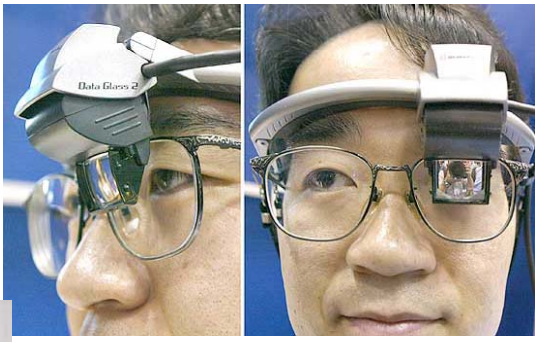
La tomba di Nefertari

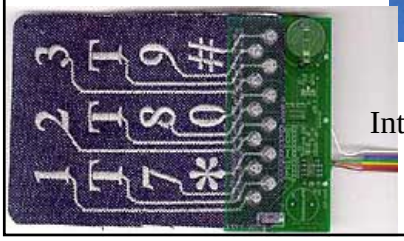
Indossatrice Virtuale

Cf. Politecnico di Losanna

Wearable devices – input / output

Characteristics: mobile, context sensitive, augmented reality.

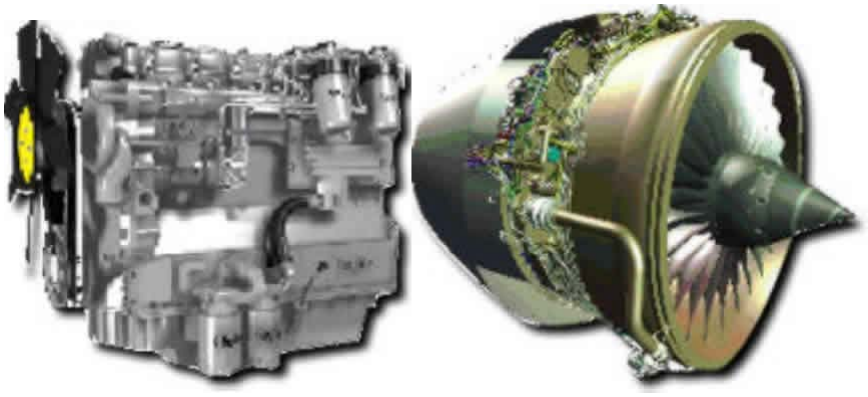




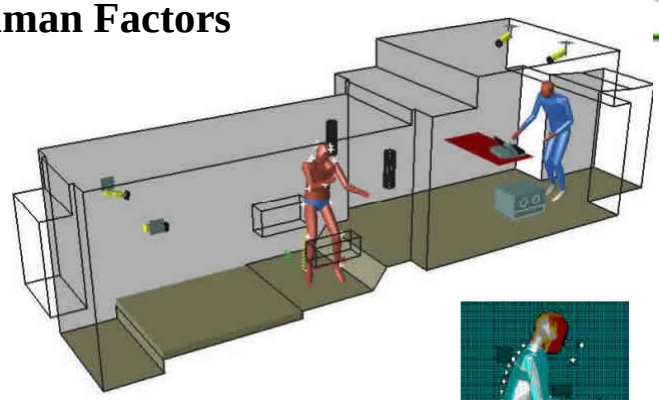
Interfaccia su stoffa.

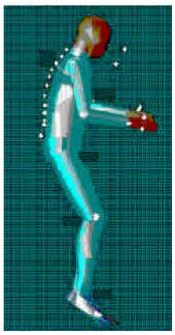
Progettazione: impianti virtuali

Progettazione: motori virtuali

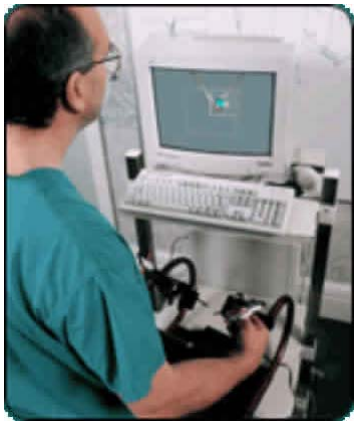


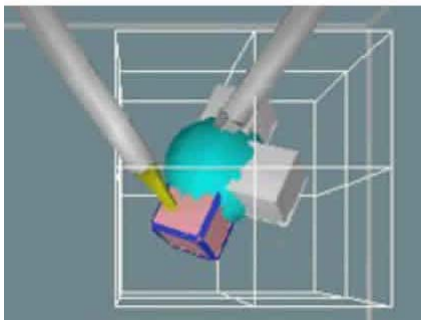
Human Factors



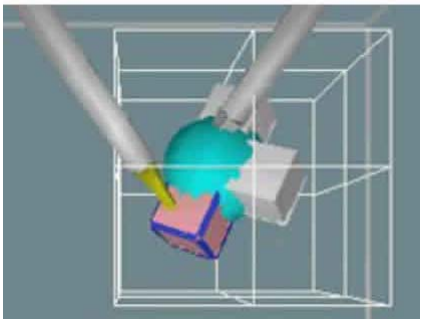


Simulazione di interventi di chirurgia mininvasiva

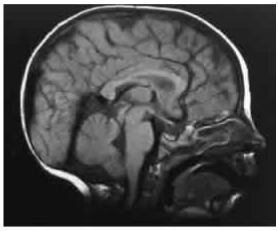


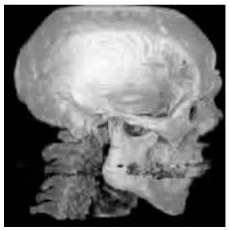


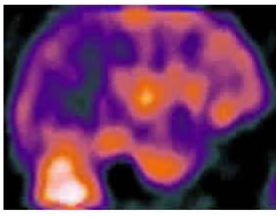
Simulazione di interventi di chirurgia mininvasiva



Fusione di immagini pre e intra operatorie



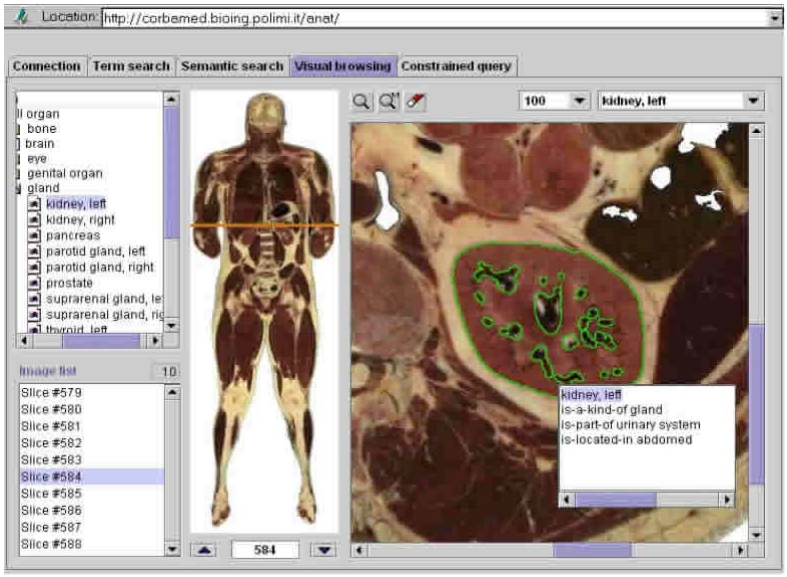




Imaging e stampanti 3D

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

Anatomia virtuale



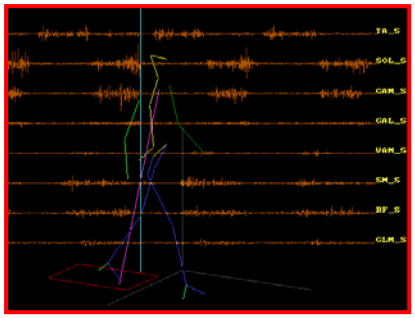
Clinical Motion Analysis

MOTION ANALYSER

FORCE TRANSDUCER

MATHEMATICAL MODELS

EMG



JOINT KINEMATICS

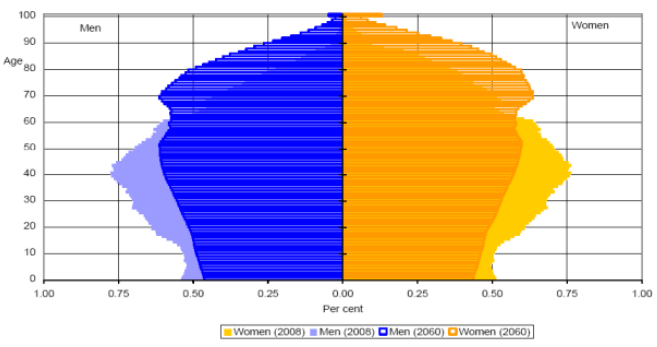
JOINT KINETICS

EXTERNAL FORCES

PLANTAR PRESSION

MUSCLE ACTIVATION AND FORCE

Rehabilitation through VR: Rewire project



Source: Eurostat, EUROPOP2008 convergence scenario

- Increase of rehabilitation need.
- National health providers are facing budget cuts.
- Prolonged intensive rehabilitation allows recovering and/or maintaining health conditions.
- Remote patients can be addressed

ICT recent developments have made possible facing the challenge

REWIRE's 3-levels platform

REWIRE's Philosophy

• Technological partners highly motivated to applications to health and rehabilitation in particular.

• Clinical partners very interested in the new possibilities offered by ICT. They define rehabilitation path and discuss with technicians how to implement it through ICT (key role of TM and ABACUS as leader or WP2).

• Industrial partners are already in the business of health ICT-based systems.

Translational bidirectional research

Better reinforced in WP9, but it is the leit-motiv of all WPs.

Implemented inside WP3 where pre-pilot testing is carried out and used to refine platform specification (Task 3.8)

2 systems will be fully tested at ETHZ and TECHNO sites before deploying REWIRE to the hospital at the clinical sites.

Scenario 1

"Joseph did not sleep well tonight. He usually exercises for rehabilitation in the morning, but this day he feels weak and distressed and does not go to his rehabilitation session. After lunch his mood drastically changes and he feels ready for rehabilitation and approaches REWIRE for his daily rehabilitation session" (accessibility issue, WP2, WP3).

"Carol is obtaining a low score today. Her REWIRE system does not detect any meaningful deviation from the previous days so the patient station is realizing that it is a matter of motivation. It slightly lowers the exercise level and speaks to the patient saying "Well Carol, your motor skills are improving, be patient, do not give up, try to hit more targets" (expert system as a feed-back, WP2, WP3).

Scenario 2

"Mrs. Mary is ready for her daily rehabilitation exercise, walks to REWIRE, attaches her lifestyle evaluation system and switches REWIRE on. REWIRE shows her the daily program and automatically downloads the daily physiological and activity data from the worn sensors and the **environmental data** directly from the ambient sensors. REWIRE analyzes the data and realizes that it is too hot and humid today to maintain the same level of exercise as the day before and tunes the game difficulty. It sends a message to both the patient and the Hospital Station and allows the patient to start her daily exercise" (adaptive the game to the patient, WP3, WP5, WP6, WP7)

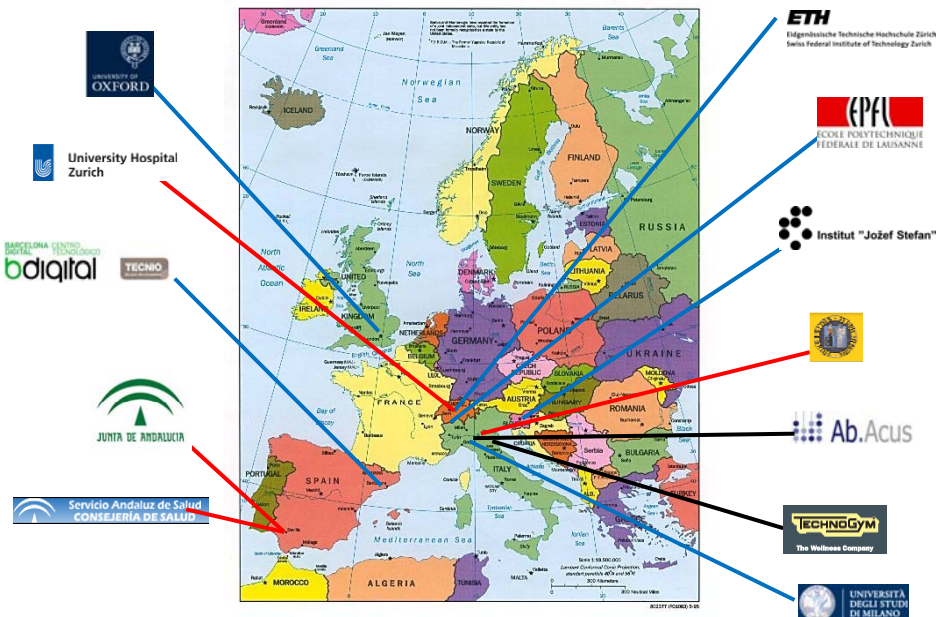
"Mr. Cottrel is approaching his REWIRE station for rehabilitation. While showing him the exercises, REWIRE downloads the physiological and environmental data and realizes that the heart rate is much higher than usual for the same amount of physical activity. It launches a warning to the hospital that makes the hospital station generate an alarm, and informs the patient that a tele-consulting session with a doctor will start soon" (direct supervision from the hospital, WP2, WP3, WP5, WP6, WP7)

Scenario 3

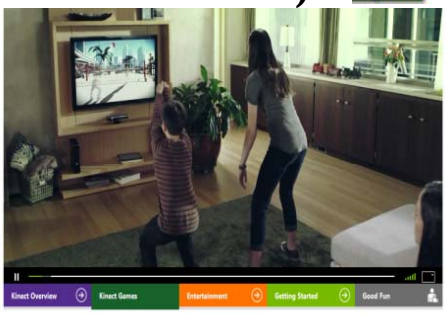
"Andreas lives in Zug and is a bit sad today. He is feeling some pin pain on his offended arm. He does not know if undergo rehabilitation today and he does not want to call the Zurich hospital. He starts his REWIRE system, gets access on the hemiplegic community with arm movement problems and asks for other patients with the same symptoms. In the blink of an eye, the name of Anna is displayed on the screen. She is currently living in Winthertur, and she is also a patient of Zurich hospital. Surprising she had a very similar story. The pin pain was waxing and veining and finally disappeared. She encourages him not to stop rehabilitation. Besides progressing happily with the therapy, Andreas became a friend of Anna and they started helping each other a lot" (patients community, WP2, WP3, WP7).

"After 2 months of intensive rehabilitation at the hospital, the possibility to continue rehabilitation at home is proposed to Mike. He adheres enthusiastically and his doctor illustrates the new at home rehabilitation program to him and shows him the REWIRE platform installed at the hospital. Before being discharged by the hospital, Mike does rehabilitation with REWIRE in the hospital under the supervision of a therapist until Mikes feels comfortable with the technology. As this would allow him going home early, Mike is particularly enthusiastic and masters REWIRE in only two days. He then trained regularly at home for six months maintaining a tight connection with the hospital, improving significantly his functional status" (smooth transition from hospital to home, WP2, WP3, WP6, WP7).

REWIRE's PARTNERS



Role of UMIL (besides coordination)



Develop mini-games to guide rehabilitation efficiently:

-Meaningful play.

- Challenging (at the right level).

- Surprise

Effectiveness.

- Graduality and continuos difficulty adaptation (maximum flexibility)

- Engaging for daily playing for a long time (controlled randomization and story board design according to clinicians needs).

- Data acquisition on motion and game interaction for analysis and tuning.

Technology.

Integration of low-cost (for massive deployment) and effective technology: Kinect, Web-cam and Balance board.

Virtual Tosca

Sommario

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