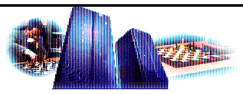
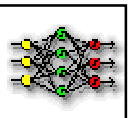



Introduzione alla Realtà Virtuale
Parte II

Alberto Borghese
Applied Intelligent Systems Laboratory (AIS-Lab)
Department of Computer Science
University of Milano

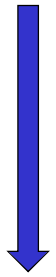

Sommario

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

VR - World generators

- Graphics Library:
  - OpenGL
  - DirectX
- 2D /3D Graphics Engines:
  - Realtime
    - Ogre3D
    - Irrlicht
    - SDL/SFML
  - Non Realtime
    - Renderman (PIXAR)
    - Arnold
    - Cycle (Blender)
- Software che usano Graphics Engines:
  - 3D modeling
    - Blender
    - Maya
    - 3D Studio Max
  - Game Engines (realtime)
    - Panda 3D
    - Unity 3D

Low level



High Level

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), trasparencies….

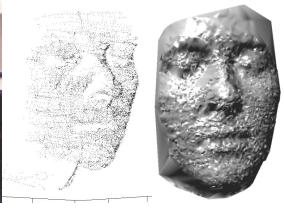
Specialized systems: Finite element models
- It is a class per sé. Local modeling. Mechnical modeling.
- Largely used for animation in medicine (facial animation, deformation of tissue during surgery). Multi-layer modeling.
- Specialized SW are usually associated: Katia, AutoCAD...
- 3D Structure.

Specific CAD for mechanics: Katia, AutoCAD, Nastran SW => **Visual Computing**

3D Assets making

- Scanners 3D
  - Active (laser or unstructured light, sound)
  - Passive (video)
- Modeling
  - Organic
  - Non organic
- Procedural

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

Which problems do you envisage?

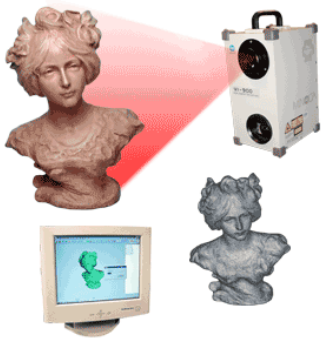
Models from range data (II)

Cyberware smaller model 3030

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

3D structure from range data (III)

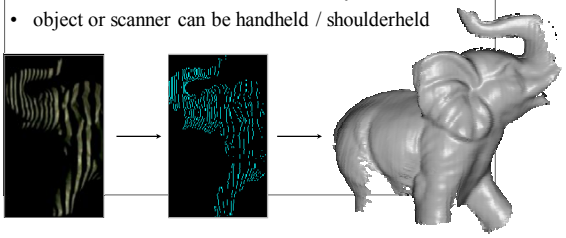
Polhemus hand held laser scanner

Research challenges Digital Michelangelo project

- 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

deo-based 3D scanner (Rusinkiewicz et al., 200

- 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)

Kinect fusion

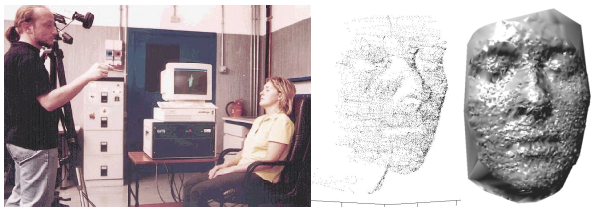
Kinect fusion

http://blogs.msdn.com/b/kinectforwindows/archive/2012/11/05/kinect-fusion-coming-to-kinect-for-windows.aspx

Low cost 3D modeling

KinectFusion: Real-time 3D Reconstruction and Interaction Using a Moving Depth Camera, Izadi et al., Proc. Siggraph 2011

From Clouds to surfaces

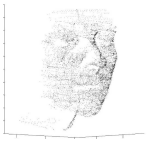


Effect of measurement noise is clear with Delaunay triangulation. Need of filtering is evident.

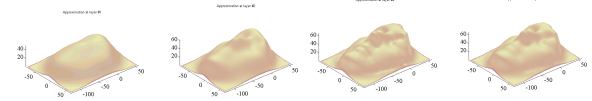
3D structure from points

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.

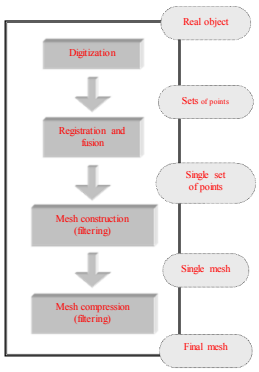
•**Surface fitting to range data**
• Snakes (Kass et al., 1988). Energy based approach. Best curves.
• Kohonen maps (1990).
• Radial Basis Functions Networks (Poggio and Girosi, 1995; Ferrari et al. 2005, semi-parametric models, incremental approach).
• Support Vector Regression (SVR, A.Smola and B.Scholkopf)



.....



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

Modellazione

Le tecniche più utilizzate attualmente :

- Poligonale -> videogiochi
- Nurbs
- SubDivision

} Forme organiche, film animazione

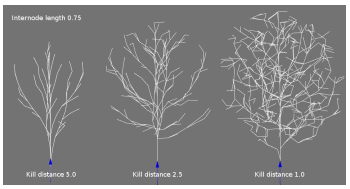
- CSG Operazioni Booleane -> Stampa 3D

Modellazione Procedurale

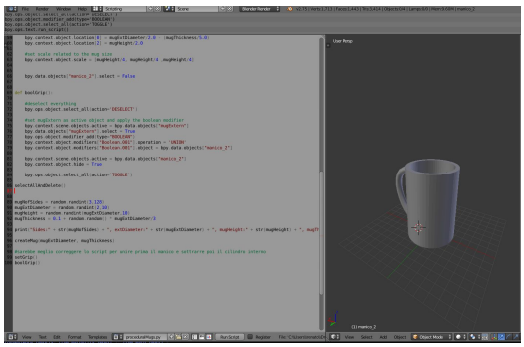
Generazione dei modelli attraverso programmi (procedure).

Risulta possibile costruire delle mesh 3D specificando delle regole di creazione parametriche.

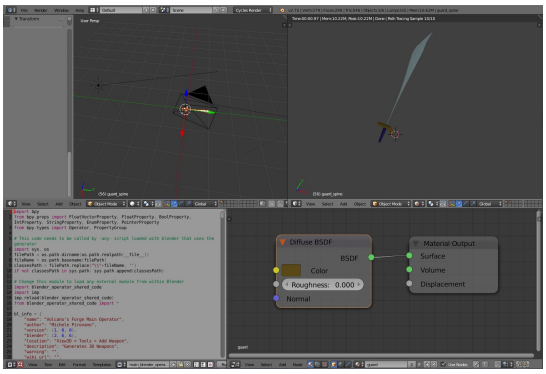
Esempi: Alberi, Abitazioni, Tazze, Spade …



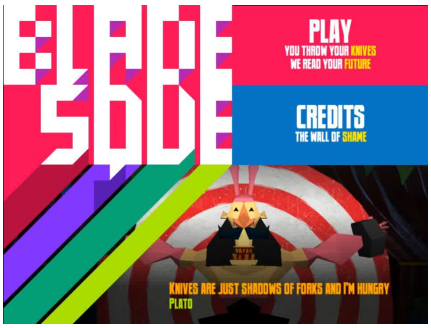
Tazze: (Stampa 3D)



Spade:



Bladesque



Sommario

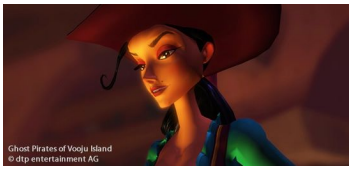
- Introduzione
- Sistemi di Input
- Generatori di mondi
- Motore Grafico
- Sistemi di Output
- Conclusioni

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

Dynastica web browser gameplay trailer.flv

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



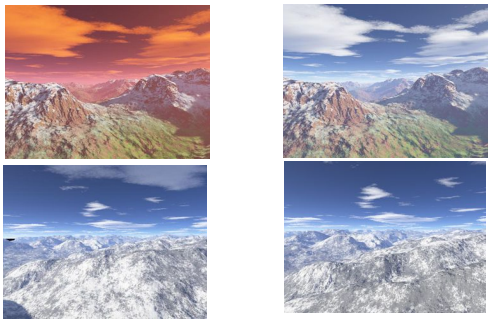
Managing collisioni detection, animation, accepting input for a wide range of devices.
It implements the game loop: reads input, changes assets (collision detection), rendering.
It loads at start time the assets that have to be created outside Panda3D (e.g. Through Maya or Blender)
(Web-cam and Kinect)

http://unity3d.com/ - Cross platform

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

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



Graphical representation

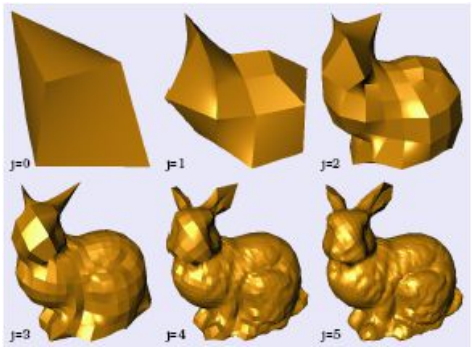
Graphical engines represent triangles => Every shape is transformed into triangles.

- The models created by the scanners are ensembles of triangles (milions of).
- Much more than required by applications.
- RealTime application -> low poly

⇓

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

LOD models

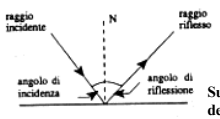


Rendering

Processo di "resa" ovvero di generazione di un'immagine a partire da una descrizione matematica di una scena tridimensionale interpretata da algoritmi che definiscono il colore di ogni punto dell'immagine digitale [Wikipedia].

Il rendering è basato sulla fisica che descrive l'interazione tra le onde elettromagnetiche (associate alla luce visibile in genere) ed un mezzo (riflessione / rifrazione / scattering / tunnelling....).

Quello che vediamo è la luce rimandata dalla scena (riflessa):



Superficie dell'oggetto

The graphical engine (visual computing)

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

Interpolation of normals direction among adjacent triangles (to create the appearence of a continous curved surface)

Graphical pipelining (from 3D geometry to 2D images: projection, colour, texture, shadowing, …).

Parallelization. GPU programming language (CUDA nVidia).

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.

VRML format -> X3D

```
#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
}
]
}
}
```


Sommario

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

Augmented Reality – Camera movement from video

Applications for smart phone (Vuforia)

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/

Direct drive manipulandum (phantom)

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

Haptics low cost

Omni Phantom

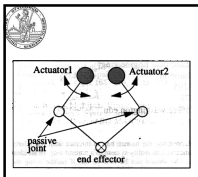
Novint Falcon

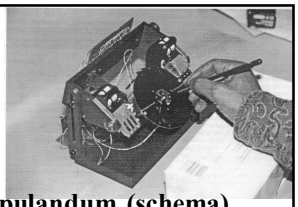
Requirements of Haptic displays

- Large bandwidth.
- Low intertial and viscosity.

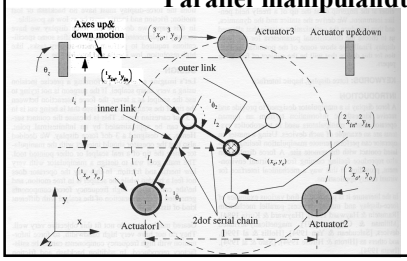
Technological solutions (oggetto intermediario):

- 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).

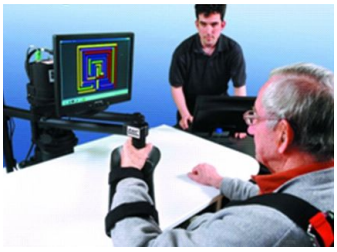




Parallel manipulandum (schema)



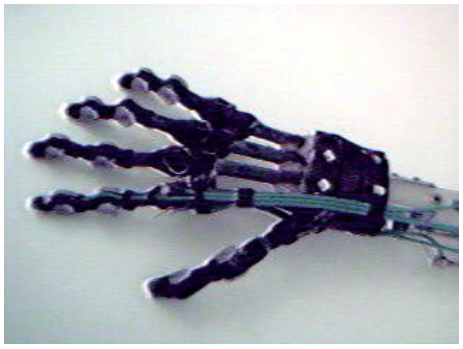
MIT-Manus, 2004



Braccio di ferro, 2010

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

Gloves (Blackfinger, 2000)



Percro glove (2002)

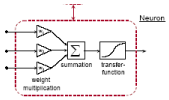
Sensori goniometrici – non devono essere calibrati sulla lunghezza delle falangi.

http://www.percro.org

Other output devices

Audio – Stereo, sound spatialization.

Olfactory – Virtual nose



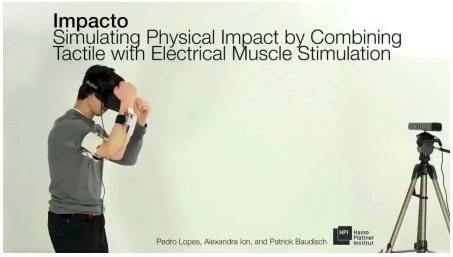
Type	Sensitive material	Detection principle
semiconducting metal oxides (M.O.S., Taguchi)	doped semiconducting metal oxides (SnO_2, GaO)	resistance change
quartz crystal microbalance, QMB surface acoustic wave, SAW	organic or inorganic layers (gas chromatography)	frequency change due to mass change
conducting 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

Il futuro ?



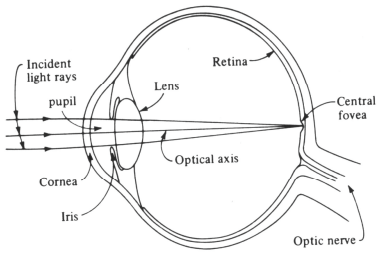
Sistemi di Output::visione

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).

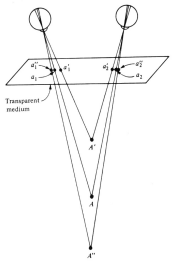
Requirements for the world generator:
•Stereoscopic vision for objects with D < 10m.
•Monocular cues for objects with D > 10m.
- - Occlusions.
- - Geometrical perspective and a-priori model knowledge.
- - Shading.
- - Motion.

L'occhio umano



Its behavior is very similar to that of a camera
Lens focuses the image, vergence movement orients the eye.

Stereo-disparity

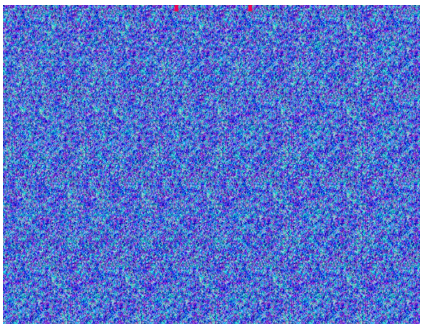


Points further away are projected on points closer to the image center.

Vergence and focusing are strictly connected.

Also monocular cues: shading, apparent size, …..

Autostereogramma



Per vedere l'imagine 3D serve togliere il pilota automatico alla convergenza e alla messa a fuoco

Passive stereo

Stereo image for passive stereo

Stereogramma con parallasse

Brevetto del 1903

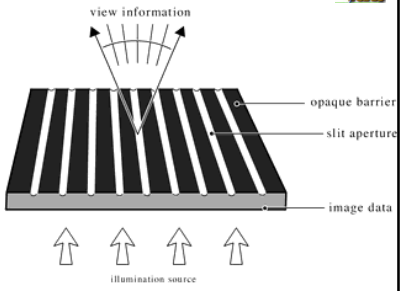
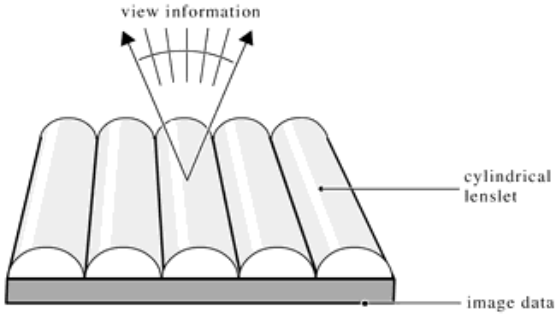


Immagine suddivisa in strisce verticali.
Coppie di strisce, associate alla parallasse orizzontale, sono posizionate in funzione dell'angolo.

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).

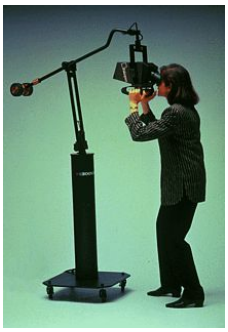
I-glasses (games)

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.



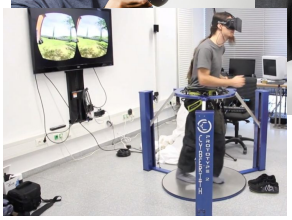
CAVE

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

More people and Complete immersivity.

Oculus Rift novel HMD: a new hype

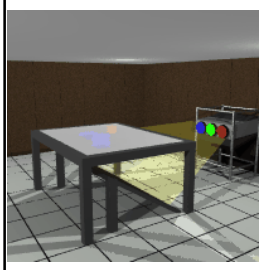
Thesis
Available



http://www.oculusvr.com/

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

VR:

Immersiva e Interattiva
(ingannare i nostro sensi)

Input utente per interagire
Simulazione del mondo virtuale
Output per farci immergere

Applications

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

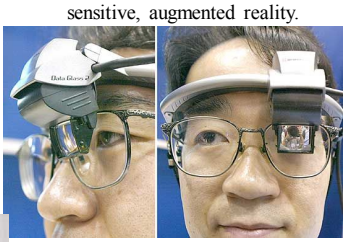
La tomba di Nefertari

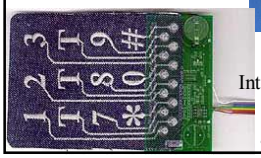
Indossatrice Virtuale

Cf. Politecnico di Losanna

Wearable devices – input / output

Characteristics: mobile, context sensitive, augmented reality.

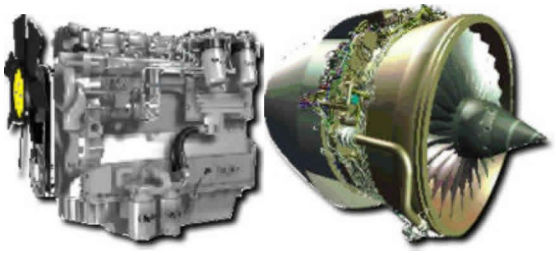




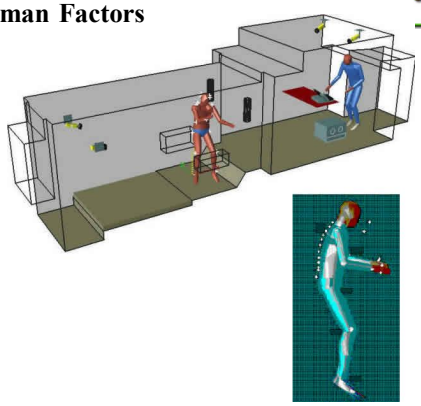
Interfaccia su stoffa.

Progettazione: impianti virtuali

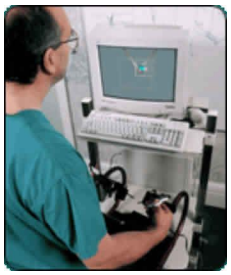
Progettazione: motori virtuali

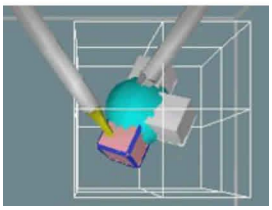


Human Factors

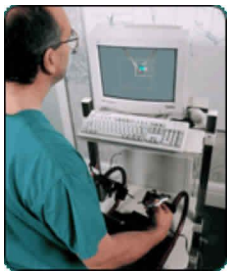


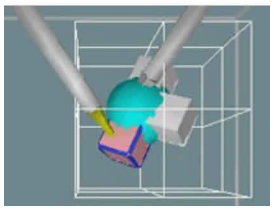
Simulazione di interventi di chirurgia mininvasiva



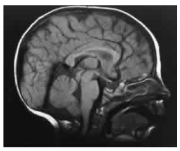


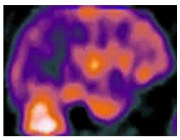
Simulazione di interventi di chirurgia mininvasiva





Fusione di immagini pre e intra operatorie

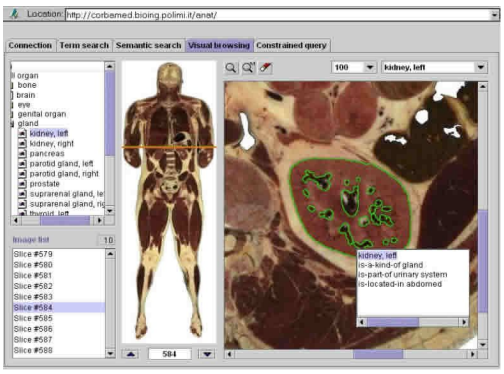




Imaging e stampanti 3D

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

Anatomia virtuale



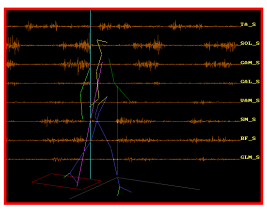
Clinical Motion Analysis

MOTION ANALYSER

FORCE TRANSDUCER

MATHEMATICAL MODELS

EMG



JOINT KINEMATICS

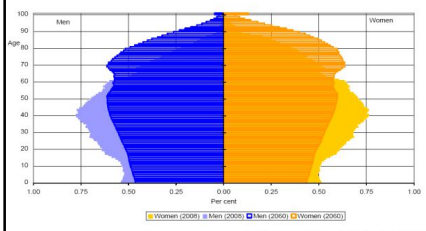
JOINT KINETICS

EXTERNAL FORCES

PLANTAR PRESSION

MUSCLE ACTIVATION AND FORCE

Rehabilitation through VR: Rewire project



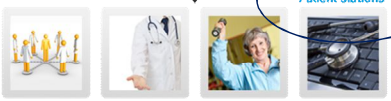
Source: Eurostat, EUROPOP2008 convergence scenario

- 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

http://www.rewire-project.eu

REWIRE's 3-levels platform



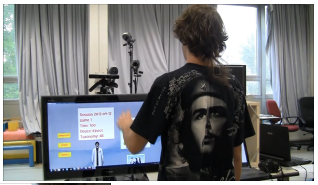
IGER – Intelligent Game Engine for rehabilitation

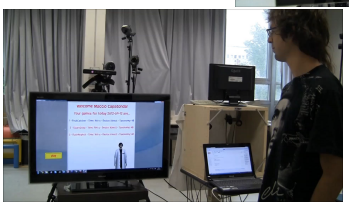
Adaptation

Monitoring

IGER – NUI interfacing

NUI interfacing





NUI interfacing
Speech recognition

Virtual Tosca

Sommario

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