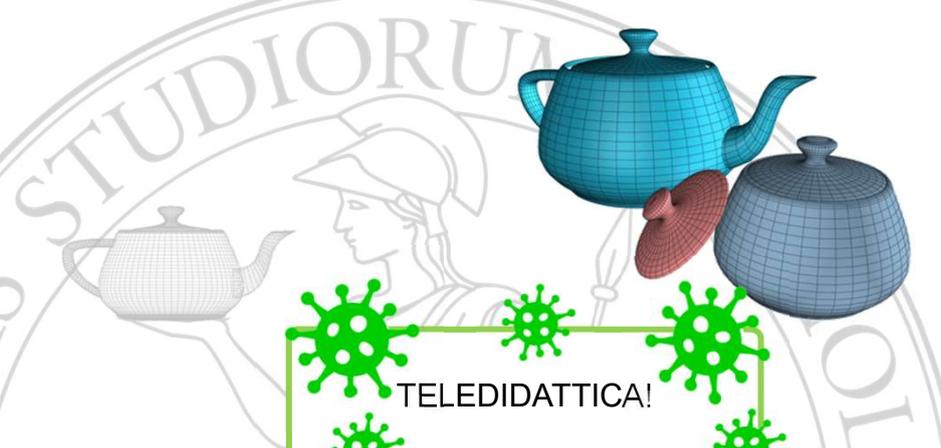


Marco Tarini - Computer Graphics 2019/2020  
Università degli Studi di Milano

Intro: cosa è e a cosa serve  
la Computer Graphics



TELEDIDATTICA!

1

A definition

CG: Computer Graphics  
a sub-field of computer science which  
studies methods for digitally synthesizing  
and manipulating **visual content**.

CGI: Computer Generated Imagery



2

## Computer Graphics: 3D

- ✓ In general terms:
  1. Digital modelling of (generally) 3D entities
  2. From those, to synthetic images
- ✓ A large fields
  - ⇒ this is an **introductory** course
- ✓ **Rapidly advancing field**
  - ⇒ in the last ~ three dozens years



3

## Computer Graphics: applicazioni

- |   |   |
|---|---|
| <ul style="list-style-type: none"><li>✓ Cultural heritage<ul style="list-style-type: none"><li>⇒ musei virtuali</li><li>⇒ supporto al restauro</li><li>⇒ supporto allo studio</li></ul></li><li>✓ Mediche<ul style="list-style-type: none"><li>⇒ supporto alla diagnosi</li><li>⇒ simulazioni, telechirurgia...</li></ul></li><li>✓ Architeturali<ul style="list-style-type: none"><li>⇒ supporto al design</li><li>⇒ previews</li></ul></li><li>✓ Manufacturing<ul style="list-style-type: none"><li>⇒ Computer Aided Design</li></ul></li></ul> | <ul style="list-style-type: none"><li>✓ Di intrattenimento<ul style="list-style-type: none"><li>⇒ Videogames</li><li>⇒ Cinema<ul style="list-style-type: none"><li>• Visual effects,</li><li>• CGI movies</li></ul></li></ul></li><li>✓ Scientifiche<ul style="list-style-type: none"><li>⇒ Scientific Visualization</li><li>⇒ Data Visualization</li></ul></li><li>✓ E-Commerce<ul style="list-style-type: none"><li>⇒ Product display</li></ul></li><li>✓ Virtual Reality<ul style="list-style-type: none"><li>⇒ augmented reality</li><li>⇒ telepresence</li></ul></li></ul> |
|---|---|



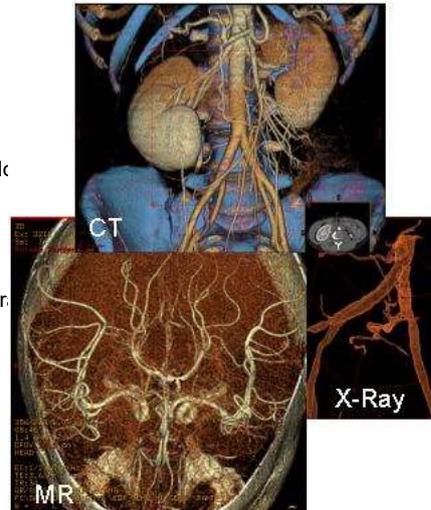
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## Computer Graphics: applicazioni

### ✓ Visualizzazione Scientifica

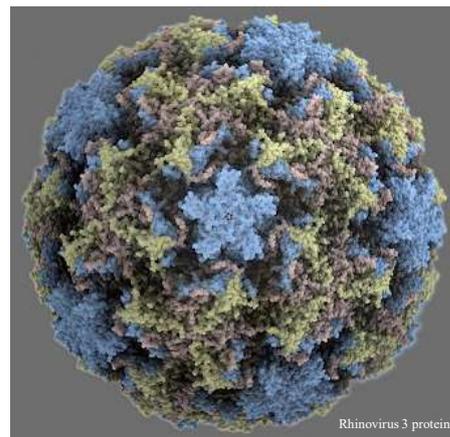
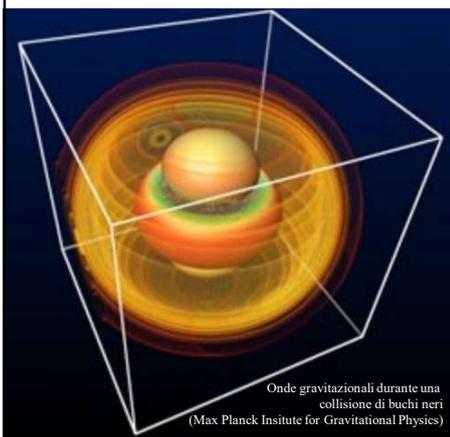
⇒ aka: SciVis , visual data

- Visualizzazione di *dati scientifici*
  - fenomeni meteorologici, medici, biol  
fisici, astrofisici,  
etc etc
- Origine dei dati:
  - l'output di una simulazione
  - *acquisiti* con qualche sistema di misur.  
Tipicamente: grandi quantità di dati



7

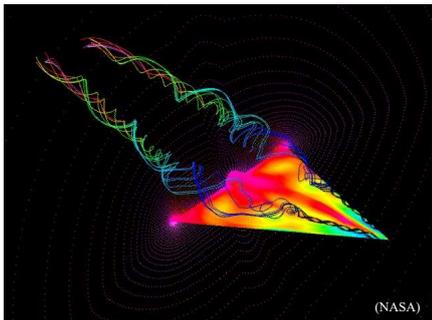
## Visualizzazione Scientifica



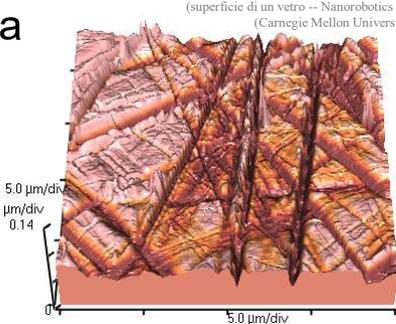
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## Visualizzazione Scientifica

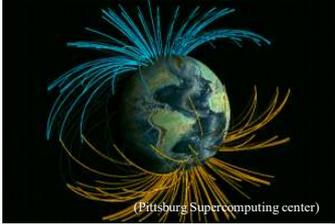
✓ Visualizzazione Scientifica  
⇒ aka: SciVis ,  
visual data analysis ...



(NASA)



(superficie di un vetro -- Nanorobotics Lab  
(Carnegie Mellon University))

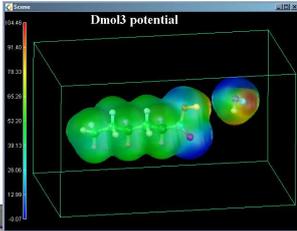


(Pittsburg Supercomputing center)

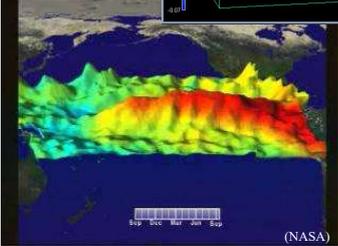
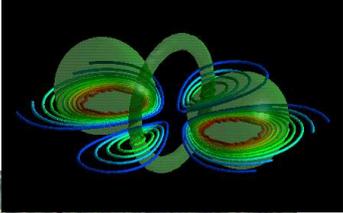
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## Visualizzazione Scientifica

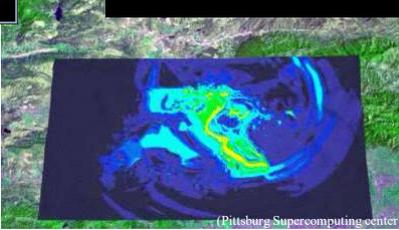
✓ Visualizzazione Scientifica  
⇒ aka: SciVis , visual data analysis ...



Dmol3 potential

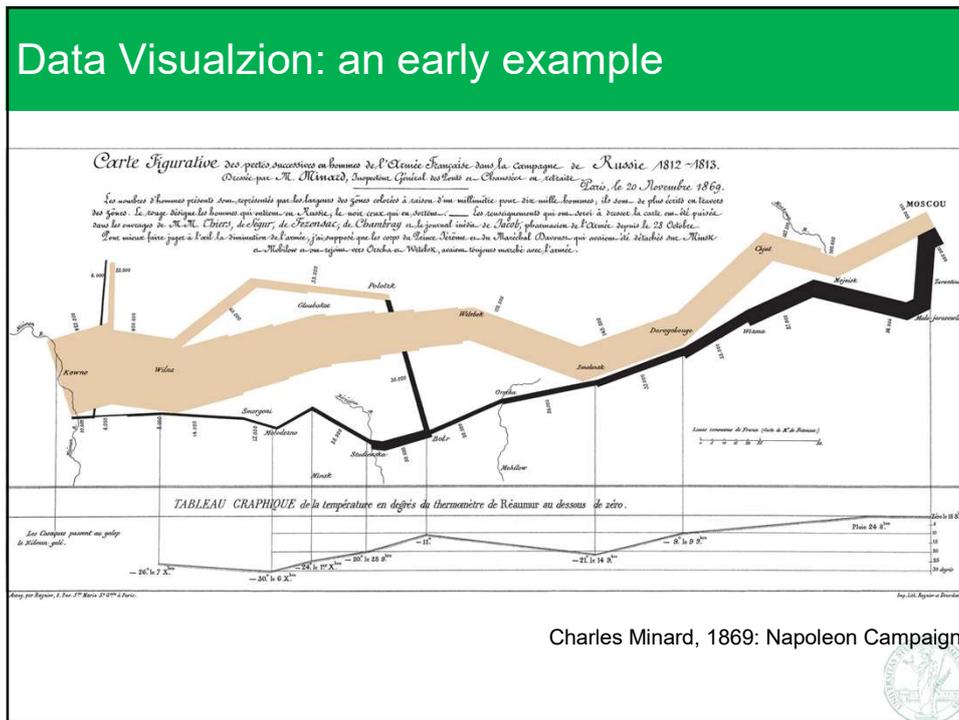


(NASA)



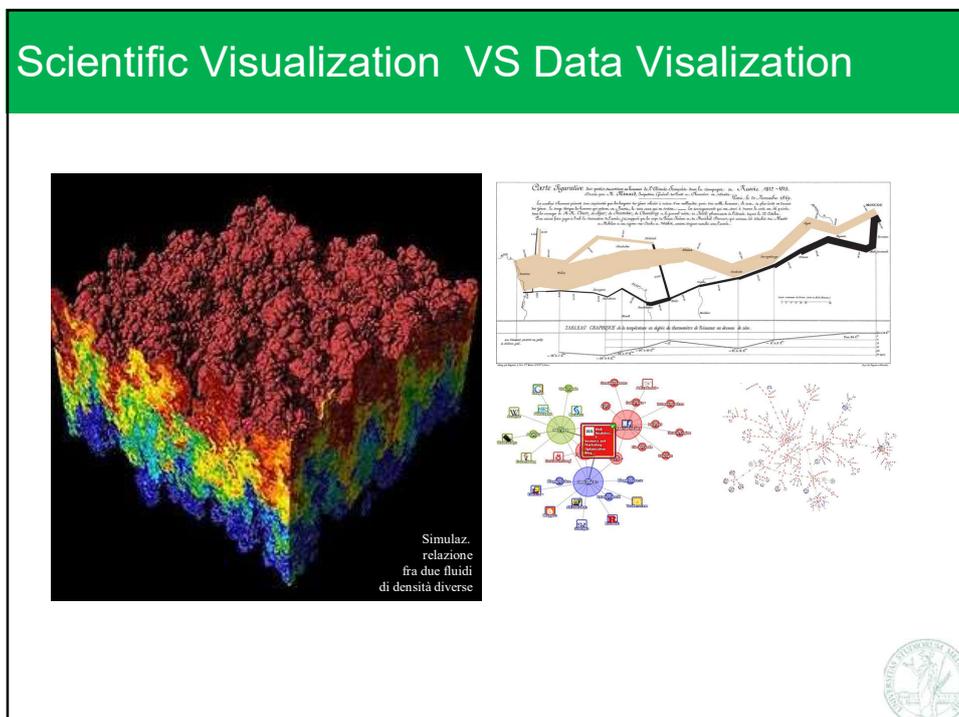
(Pittsburg Supercomputing center)

10



Charles Minard, 1869: Napoleon Campaign

13



14

## Scientific Visualization VS Data Visualization

- |  |  |
|--|--|
| <ul style="list-style-type: none"><li>✓ <b>dati</b> con un interpretazione 3D “naturale”<ul style="list-style-type: none"><li>⇒ spesso:<ul style="list-style-type: none"><li>+ dimensione tempo</li></ul></li></ul></li><li>✓ <b>Scopo:</b> chiarezza/leggibilità</li><li>✓ <b>Mezzi:</b> realismo, oppure ...</li></ul> | <ul style="list-style-type: none"><li>✓ <b>dati</b> astratti (N dimensionali)</li><li>✓ <b>Scopo:</b> chiarezza/leggibilità</li><li>✓ <b>Mezzi:</b> i più vari</li></ul> |
|--|--|



15

## Computer Graphics: applicazioni

- |  |   |
|--|---|
| <ul style="list-style-type: none"><li>✓ <b>Cultural heritage</b><ul style="list-style-type: none"><li>⇒ musei virtuali</li><li>⇒ supporto al restauro</li><li>⇒ supporto all'analisi</li><li>⇒ monitoring</li></ul></li><li>✓ <b>Medicina</b><ul style="list-style-type: none"><li>⇒ supporto alla diagnosi</li><li>⇒ telechirurgia</li><li>⇒ simulazioni</li></ul></li><li>✓ <b>Architetturali</b><ul style="list-style-type: none"><li>⇒ Supporto al design</li><li>⇒ Previews</li></ul></li><li>✓ ...</li></ul> | <ul style="list-style-type: none"><li>✓ <b>Videogiochi</b></li><li>✓ <b>Cinematografia</b><ul style="list-style-type: none"><li>⇒ <i>Visual effects</i></li><li>⇒ Film di animazione</li></ul></li><li>✓ <b>Scientific Visualization</b></li><li>✓ <b>Manufacturing industry</b><ul style="list-style-type: none"><li>⇒ e.g. Computer Aided Design</li></ul></li><li>✓ <b>Telecommunications</b><ul style="list-style-type: none"><li>⇒ Personalized Avatars</li><li>⇒ E-commerce</li></ul></li><li>✓ <b>Virtual Reality</b><ul style="list-style-type: none"><li>⇒ e augmented reality</li></ul></li></ul> |
|--|---|

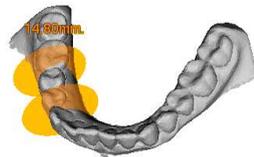
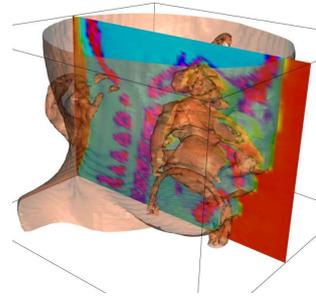


16

## Computer Graphics: applicazioni

### ✓ applicazioni medicali

- ⇒ supporto alla diagnosi
  - e.g. visualizz. CAT scans
- ⇒ chirurgia virtuale
- ⇒ tele-chirurgia

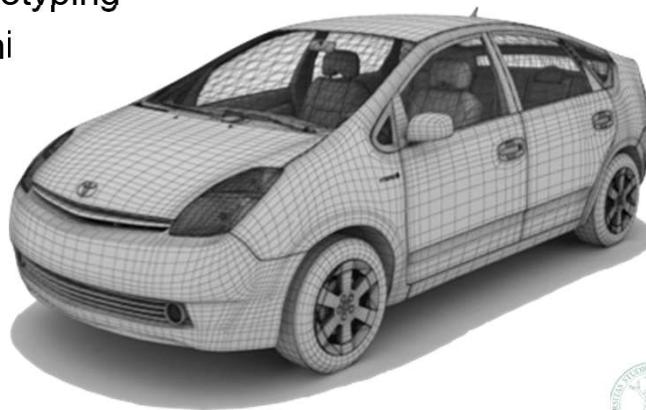


18

## Computer Graphics: applicazioni

### ✓ Industria Manifatturiera

- ⇒ CAD
- ⇒ Rapid Prototyping
- ⇒ Simulazioni (e.g. FEM)
- ⇒ ...

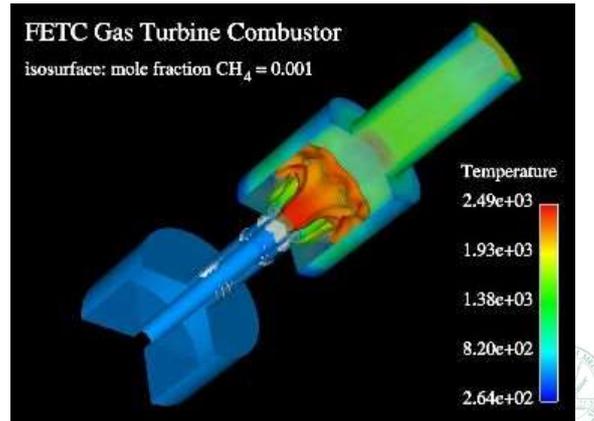


19

## Computer Graphics: applicazioni

### ✓ Industria Manifatturiera

- ⇒ CAD
- ⇒ Rapid Prototyping
- ⇒ Simulazioni (e.g. FEM)
- ⇒ ...



20

## Computer Graphics: applicazioni

### ✓ Entertainment: movie industry

- ⇒ visual effects (non special fx)



21

## Effetti *Visuali* VS Effetti Speciali



• (in post-produzione)



(sul set)  
(es: stuntmen, corde, esplosioni, ...)

22

## Computer Graphics: applicazioni

- ✓ Entertainment: movie industry
  - ⇒ CG shorts
  - ⇒ Feature movies



Geri's Game - Pixar 1997



Toy Story - Pixar 1995



24

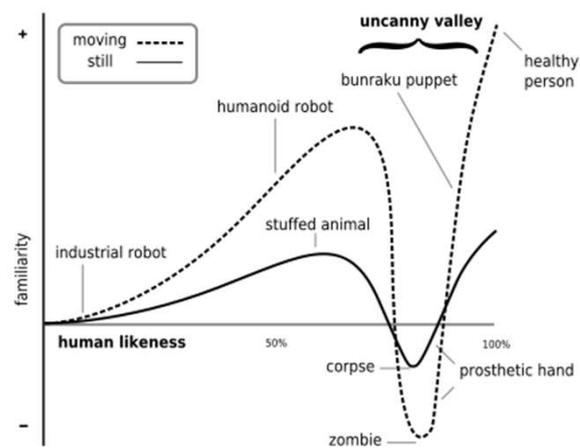
## Computer Graphics: applicazioni

- ✓ Entertainment: movie industry
  - ⇒ Feature movies fotorealistici



25

## Uncanny valley



26

## Computer Graphics: applicazioni

- ✓ Entertainment: giochi
  - ⇒ forza trainante del settore (crederci o no) ...



27

## Computer Graphics: applicazioni

- ✓ Entertainment: giochi
  - ⇒ forza trainante del settore (crederci o no) ...



28

## Computer Graphics: appl

- ✓ Entertainment: giochi
  - ⇒ forza trainante del settore (crederci o no) ...



Doom 3 - ID soft 2004

World of Warcraft, Blizzard Entertainment 2004

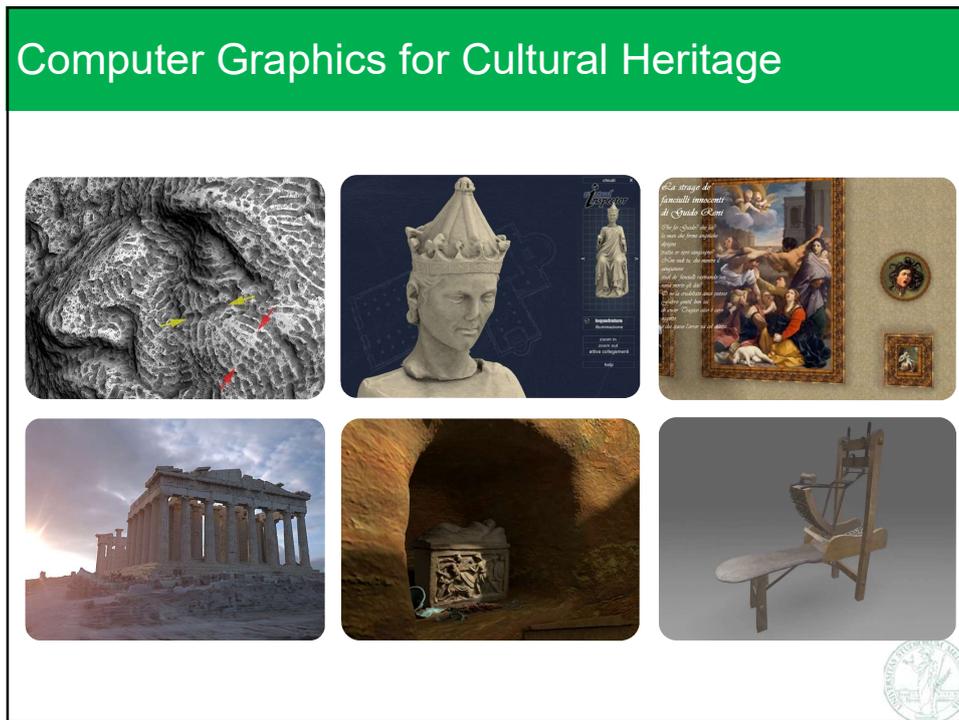
29

## Applicazioni della CG

- ✓ Entertainment: videogames



30



31

## Uso di modelli 3D nei Beni Culturali

Uno strumento per:

- ✓ **Supporto alla fruizione / Presentazione**
  - ⇒ esempi:  
musei virtuali, chioschi interattivi in musei reali, presentazioni web, televisive...
- ✓ **Supporto alla catalogazione:**
  - ⇒ documentazione
  - ⇒ domino a cui associare altre informazioni («GIS per oggetti 3D»)
- ✓ **Supporto all'indagine / studio**
  - ⇒ supporto al restauro
  - ⇒ rilevazione, simulazione fisica
  - ⇒ visualizzazione scientifica

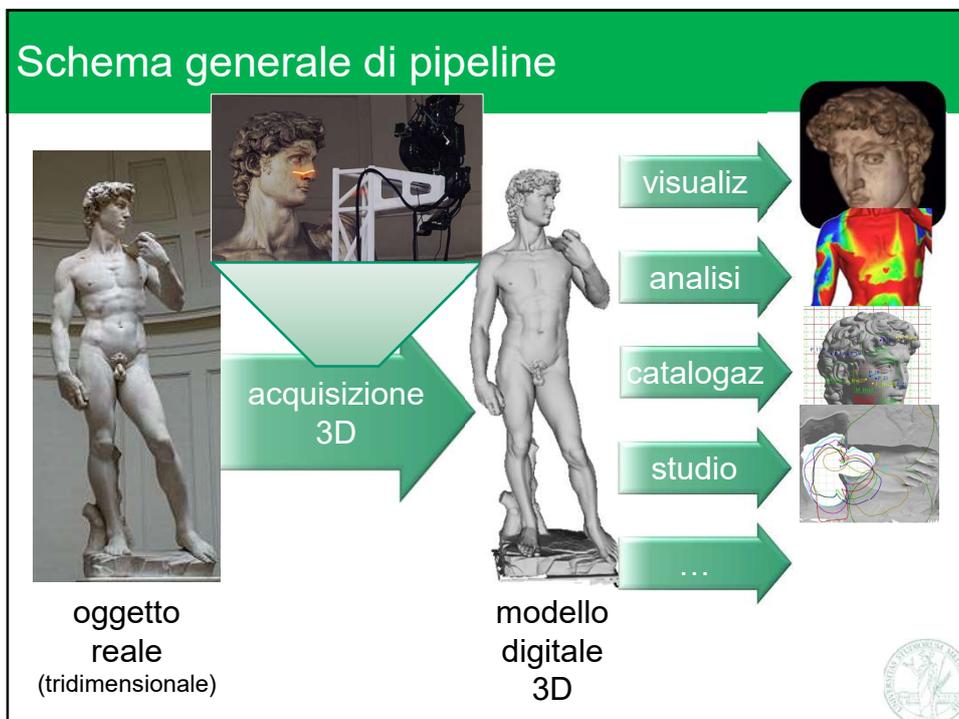


32

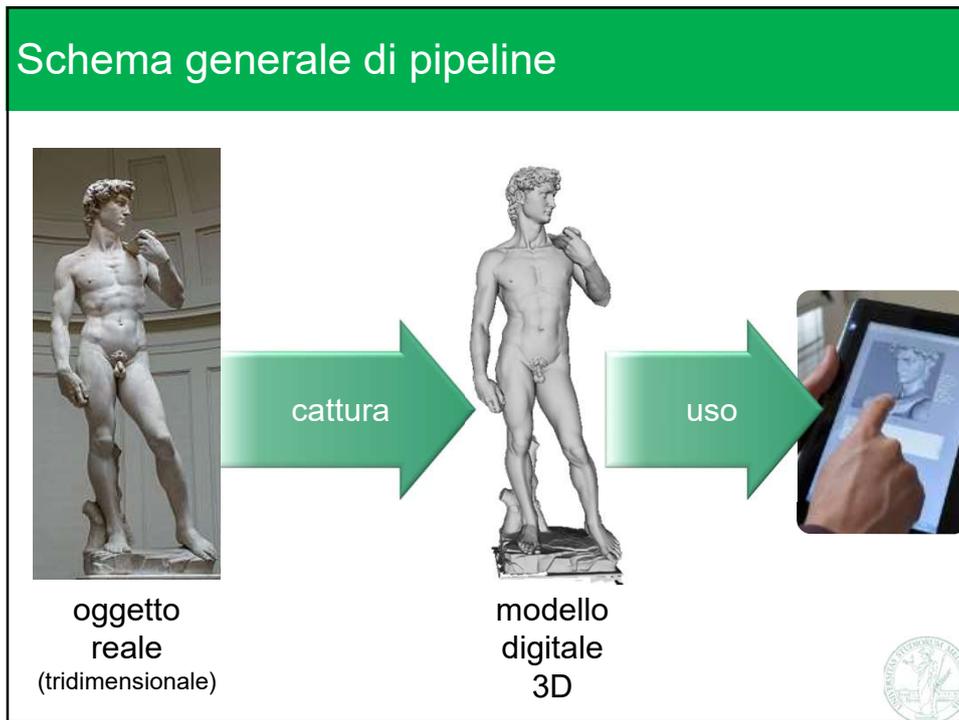
## CG for Cultural Heritage

### Case study: Michelangelo project

33



34



35

### Beni Culturali: Restauro

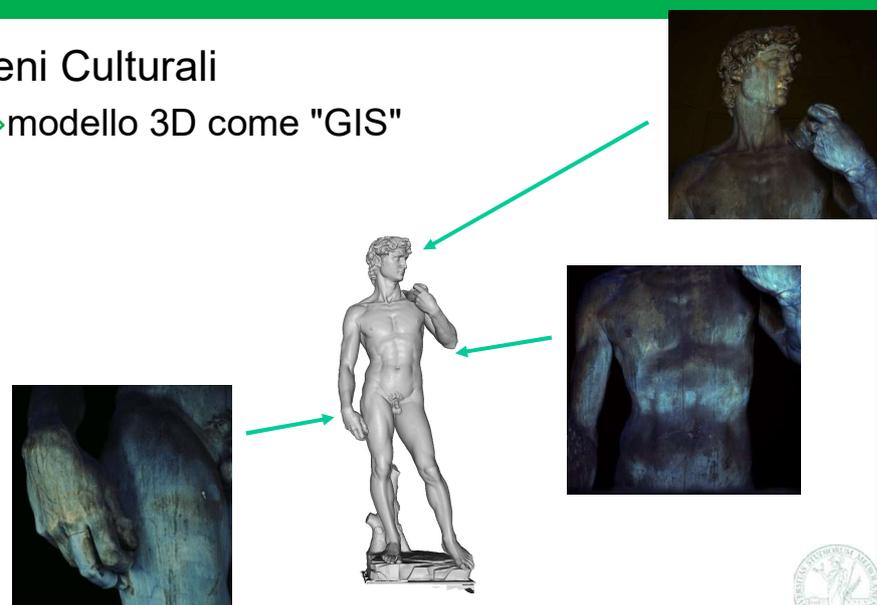
- ✓ Il restauratore si faceva fare degli schizzi su carta dell'opera da restaurare per fare una mappa degli interventi: col il modello virtuale può gestire tutto su PC
- ✓ Acquisizione dell'opera prima e dopo il restauro e confronto geometrico delle differenze

The image shows three 3D models of David's statue. The first two are front and side views with red dots and labels (e.g., "R100", "R101") indicating restoration points. The third is a back view with red dots and labels (e.g., "R102", "R103"). To the right is a close-up of the head with a green grid overlay and various colored markers and labels (e.g., "P.17", "P.20", "P.21", "Eive21", "L. Eive22", "M. Base", "Eive2", "Eive3").

38

## Computer Graphics: applicazioni

✓ Beni Culturali  
⇒ modello 3D come "GIS"

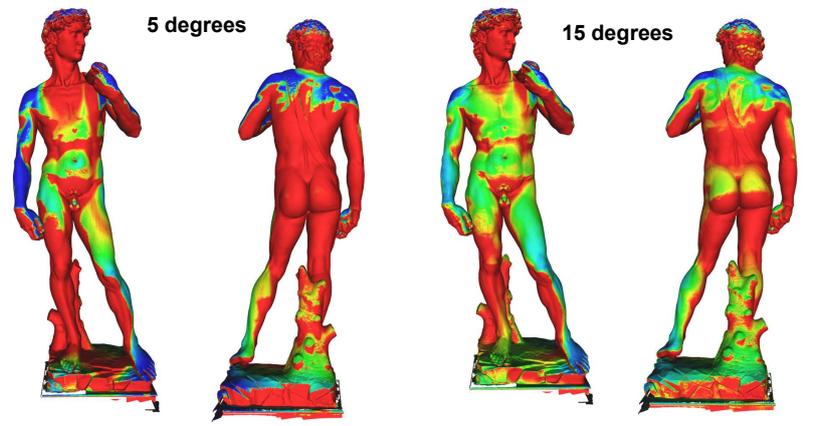


The slide features a central 3D model of Michelangelo's David statue. Three green arrows point from the model to three inset photographs: the top-right inset shows the statue's head and right hand; the middle-right inset shows the torso; the bottom-left inset shows the left hand. A small circular logo of the University of Milan is in the bottom right corner.

39

## Beni Culturali: Studio

✓ ES: Simulazione caduta contaminanti



The slide displays four 3D models of Michelangelo's David statue, arranged in two pairs. The first pair is labeled "5 degrees" and the second pair is labeled "15 degrees". Each model is color-coded to show the distribution of contaminant deposition, with red indicating high concentration and blue indicating low concentration. A small circular logo of the University of Milan is in the bottom right corner.

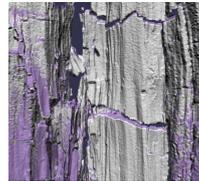
40

## Beni Culturali: Monitoraggio

- ✓ es: monitorare nel tempo la variazioni sui materiali deformabili



foresta di Duna Robba  
<http://www.forestafossile.it/public/new/>



41

## Computer Graphics: applicazioni

- ✓ Cultural heritage
  - ⇒ musei virtuali
  - ⇒ supporto al restauro
  - ⇒ supporto all'analisi
  - ⇒ monitoring
- ✓ Medicina
  - ⇒ supporto alla diagnosi
  - ⇒ telechirurgia
  - ⇒ simulazioni
- ✓ Architetture
  - ⇒ Supporto al design
  - ⇒ Previews
- ✓ ...
- ✓ Videogiochi
- ✓ Cinematografia
  - ⇒ *Visual effects*
  - ⇒ Film di animazione
- ✓ Scientific Visualization
- ✓ Manufacturing industry
  - ⇒ e.g. Computer Aided Design
- ✓ Telecommunications
  - ⇒ Personalized Avatars
  - ⇒ E-commerce
- ✓ Virtual Reality
  - ⇒ e augmented reality

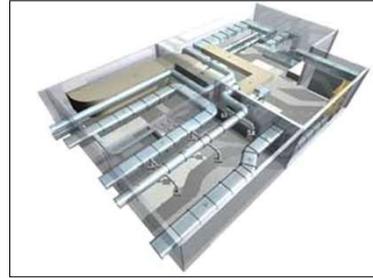
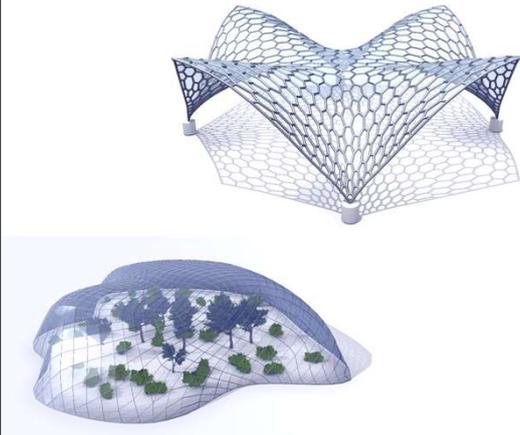


45

## Computer Graphics: applicazioni

### ✓ Architettura:

⇒ supporto al design



46

## Computer Graphics: applicazioni

### ✓ Architettura:

⇒ preview:

- comunicazione
- assessment
- supporto al design



47

## Computer Graphics – applicazioni: VR



48

## Summary

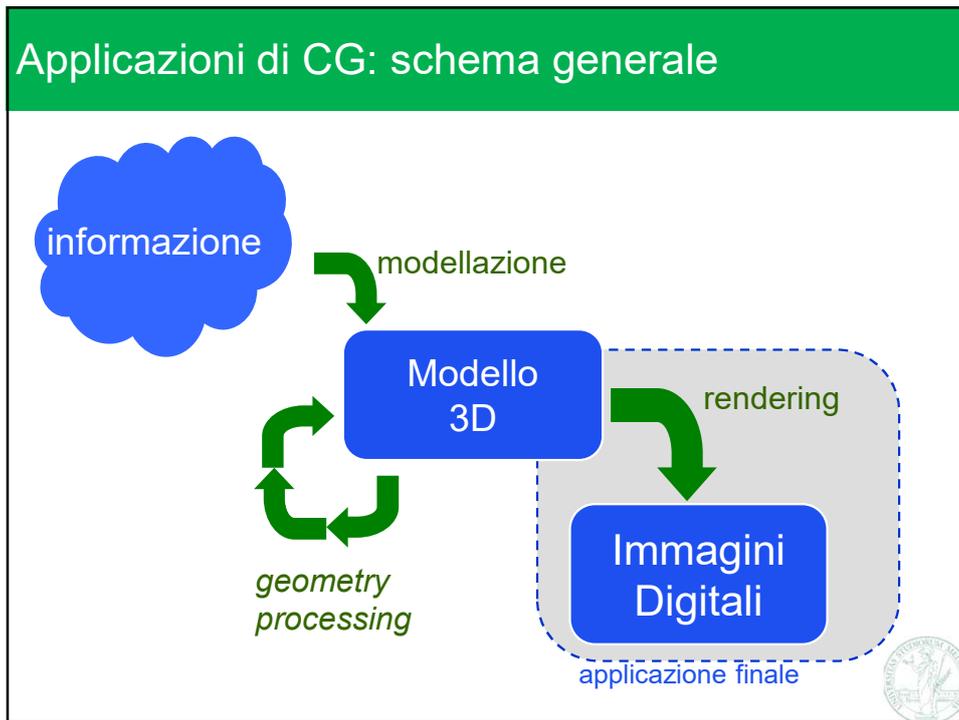
### ✓ Grafica Computazionale (Computer Graphics - CG):

⇒ molteplici applicazioni

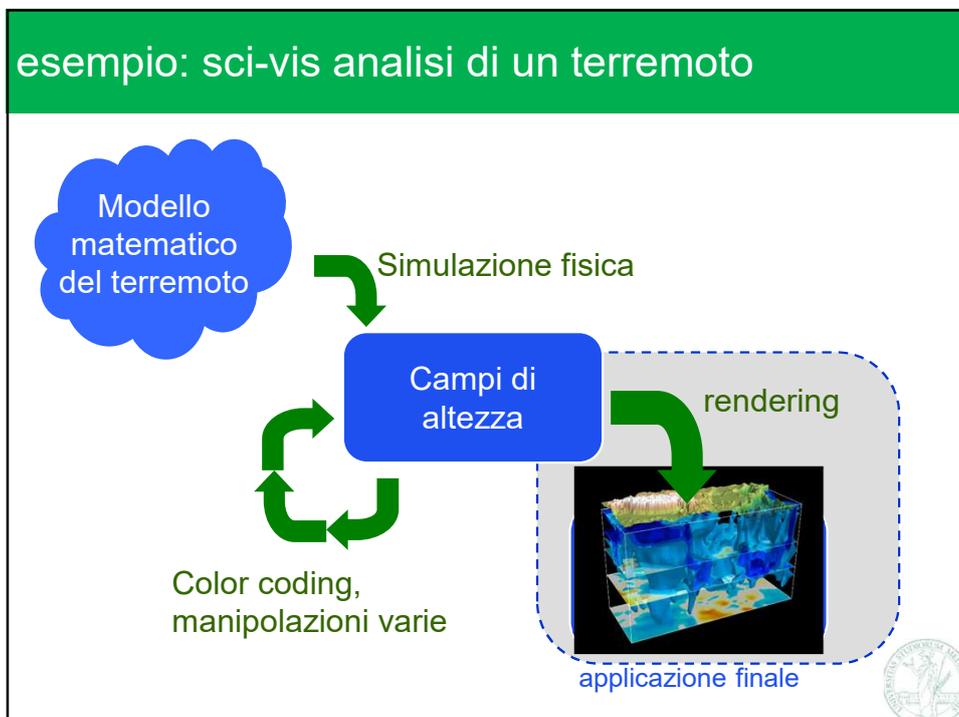
- medicali
- industriali
- beni culturali
- militari ☹
- telecomunicazioni
- commerciali
- ricerca scientifica (scivis)
- intrattenimento: games
- intrattenimento: movies
- e altro (realta' virtuale....)



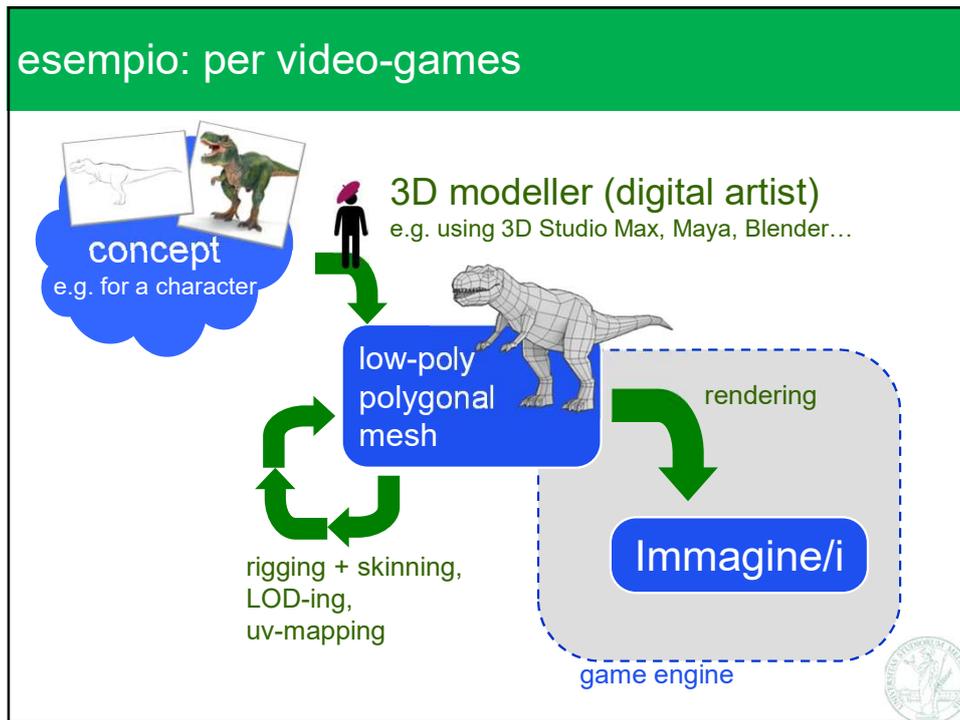
49



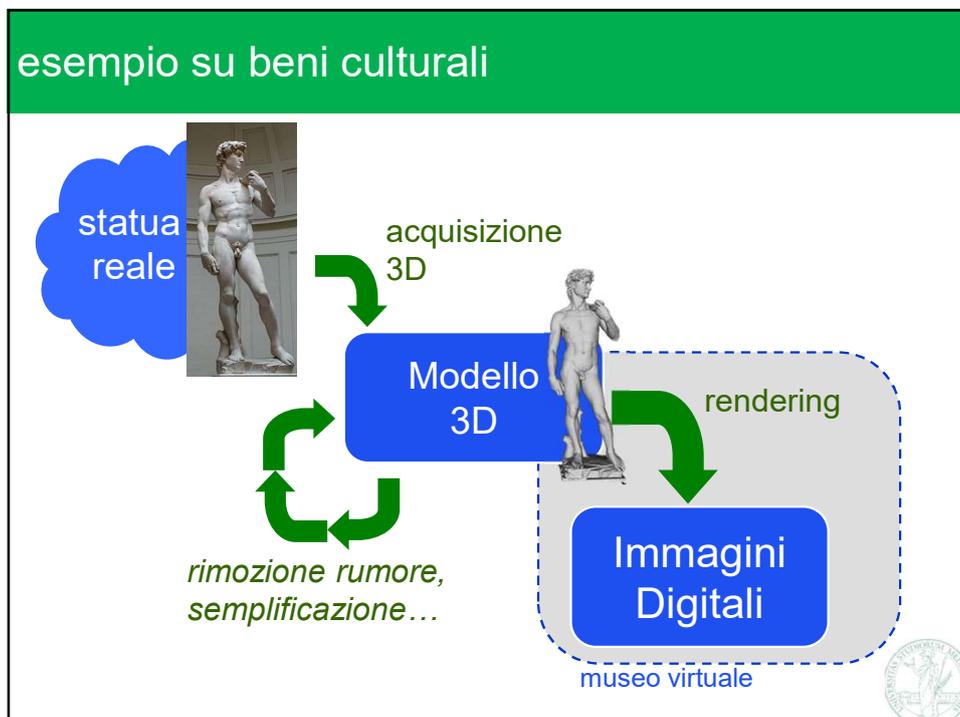
50



51



52



53



## Rendering

✓ In our context

3D Model

➔

Digital Image

3D rendering



56

## Rendering

✓ Rendering 3D

```

Obj:
  102, 103, 104, 105, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 |
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```

## Algoritmi di Rendering

### ✓ Due tipi:

#### ⇒ On-Line Rendering

- Interattivo: circa 1 – 10 frames per sec ("fps")
- Real-Time: circa 10-100 fps

#### ⇒ Off-line Rendering

- Tipicamente: da minuti ad ore per fotogramma

### ✓ Molto differenti:

- ⇒ nelle applicazioni possibili
  - ⇒ nei vincoli necessari
  - ⇒ nella qualità visiva raggiunta (e.g. fotorealismo)
  - ⇒ nel tipo e risoluzione dei modelli 3D usati
- insomma: approcci diversi, mondi diversi.



58

## Real Time VS Offline rendering

### ✓ Distanza si accorcia

1993



real time



offline



59

## Real Time VS Offline rendering

✓ Distanza si accorcia

2001



nVIDIA tech demo at SIGGRAPH 2001  
nVIDIA quadro



Final Fantasy - Squaresoft 2001

real time

offline



Jurassic Park - Universal Studios 1993

60

## Real Time VS Offline rendering

✓ Distanza si accorcia

2007



GPU Gems III, d'Eon & Lumbke (Nvidia), 2007



Spiderman 3 - Squaresoft 2007

real time

offline



Jurassic Park - Universal Studios 1993

61