Il colore: acquisizione e visualizzazione

17-22 Maggio 2018

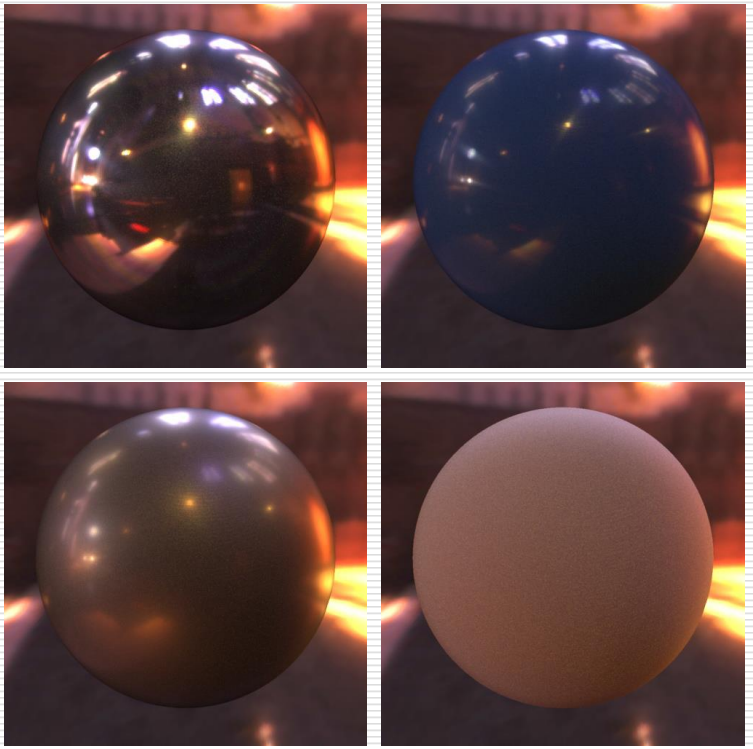
Visual Appearance

Visual Appearance

Color due to the interaction between the lighting environment (intensity, position, …) and the properties of the object surface and material.

LIGHT

MATERIAL



Visual Appearance: why?

Photorealistic rendering – High fidelity reproduction of the real world

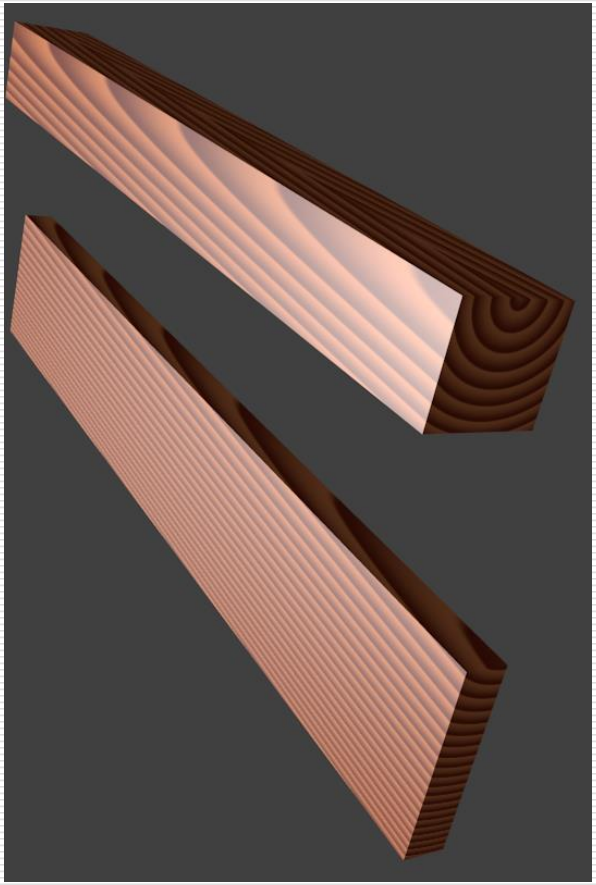
PHOTO **RENDERING**

Visual Appearance: why?

Perception – Better understanding of the details (even with a fake appearance)

Visual Appearance: why?

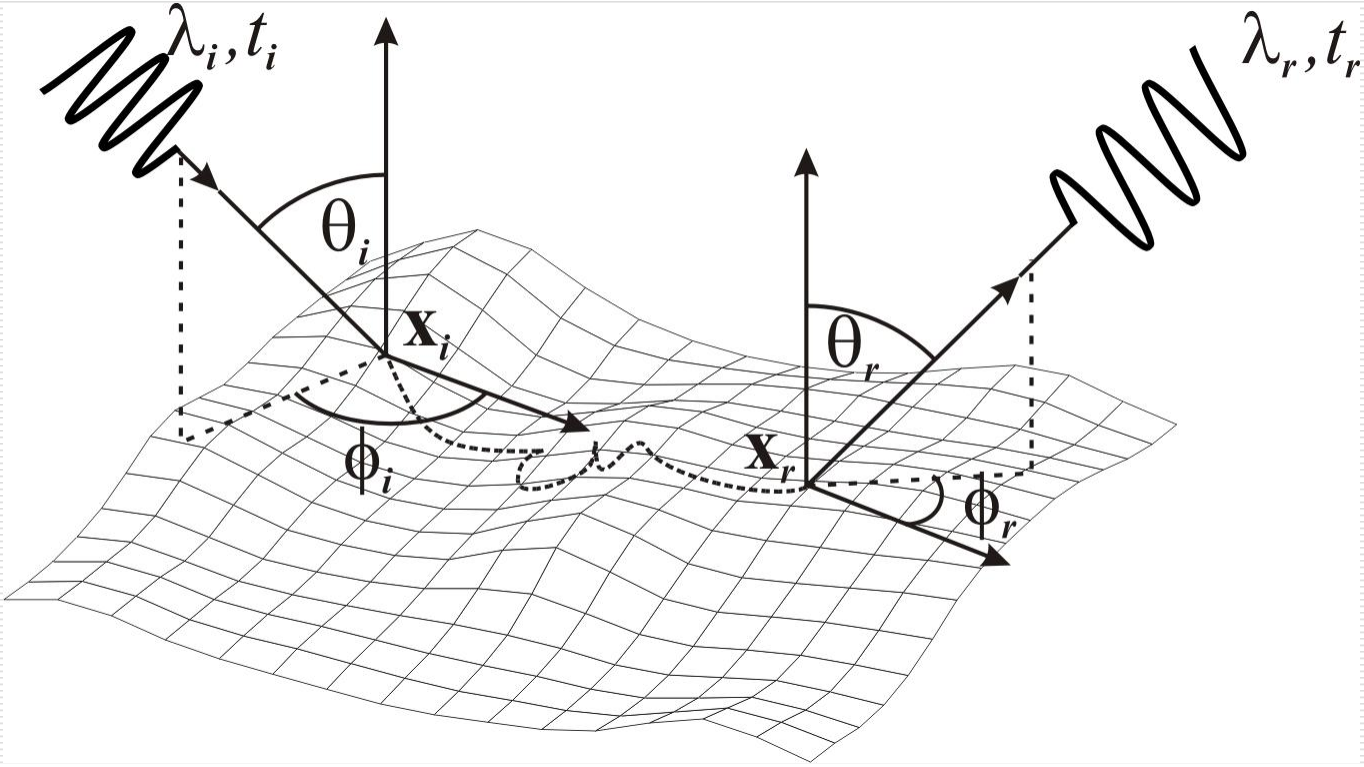
To infer more cognitive data from color details



Visual Appearance: Definition

Reflectance Scattering Function (12D)

(Light and view direction, Incident and outgoing surface point Wavelength, Time)

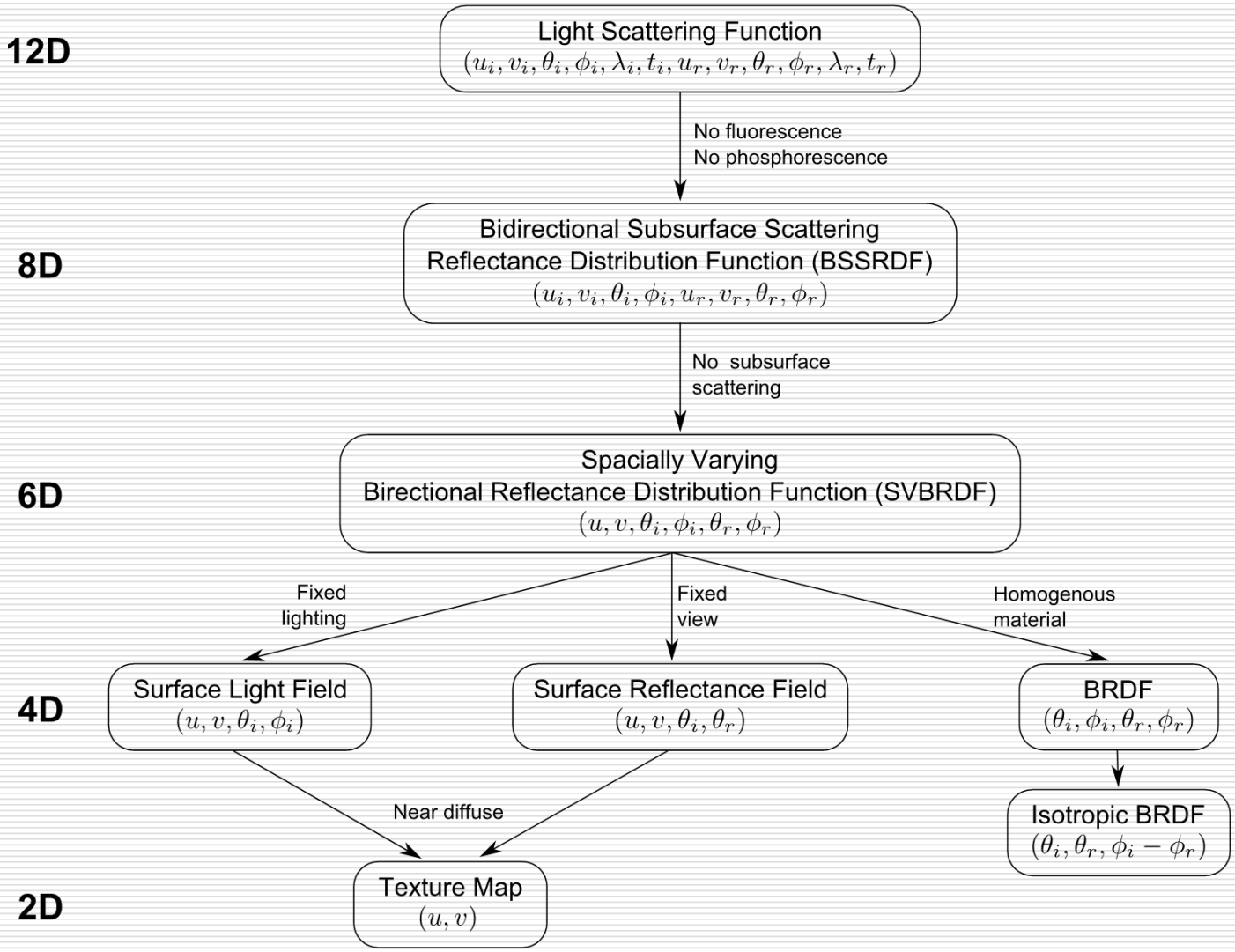


Visual Appearance: Definition

Reflectance Scattering Function (12D)

- No mathematical formulation
- Measurement impractical
- Simplification by constrains on the set of possible reflectance effects
  - Phosphorescence
  - Fluorescence
  - Subsurface scattering
  - Specular scattering
  - Backscattering
  - Diffuse scattering

Visual Appearance: Definition



Visual Appearance

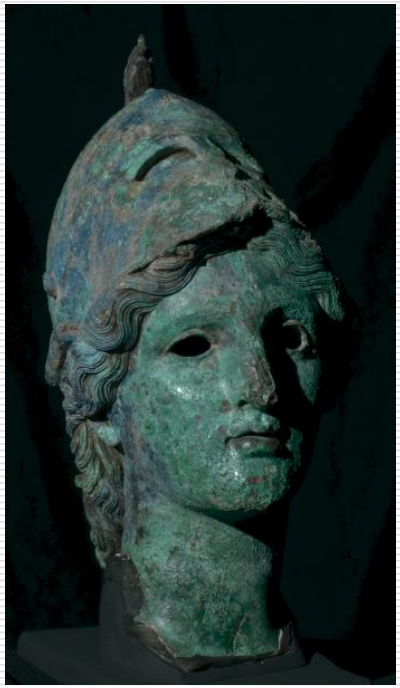
BSSRDF (8D)

- No fluorescence (no wavelength change)
- No Phosphorescence (zero time light transport)
- Subsurface scattering (translucent material)

Visual Appearance

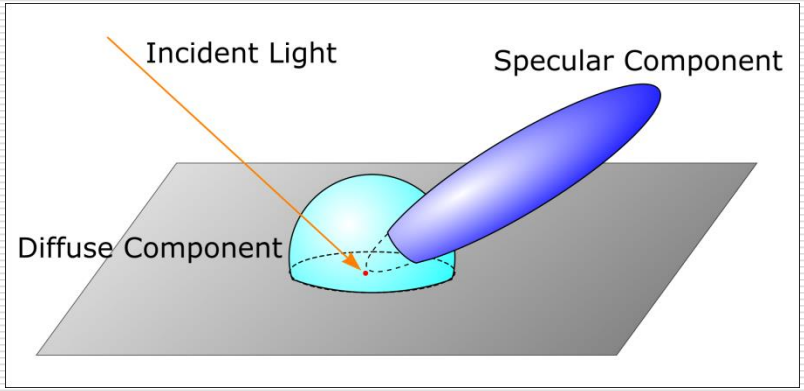
SVBRDF (6D)

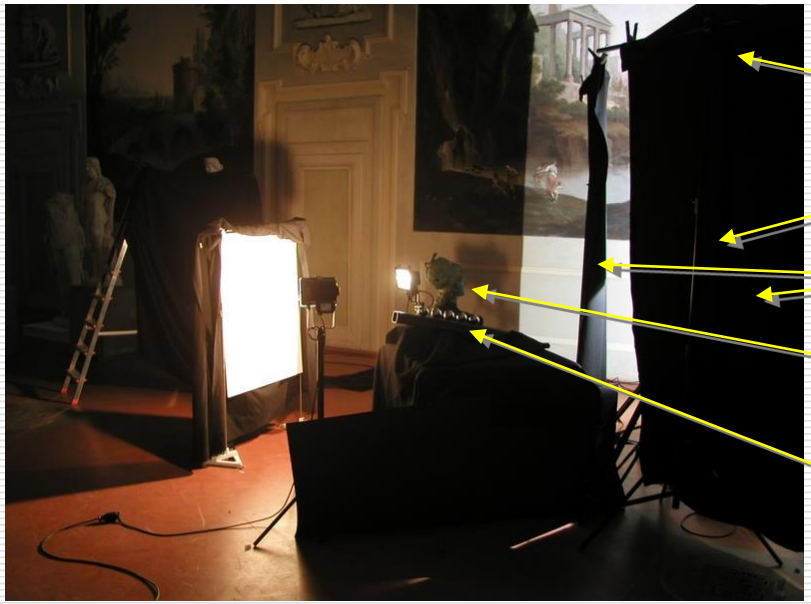
- No Subsurface scattering (translucent material)
- Opaque material (reflection on the same place)
- Spatially varying glossy material



SVBRDF acquisition

BRDF(θi,Φi,θo,Φo,u,v)





light source

camera

black felt

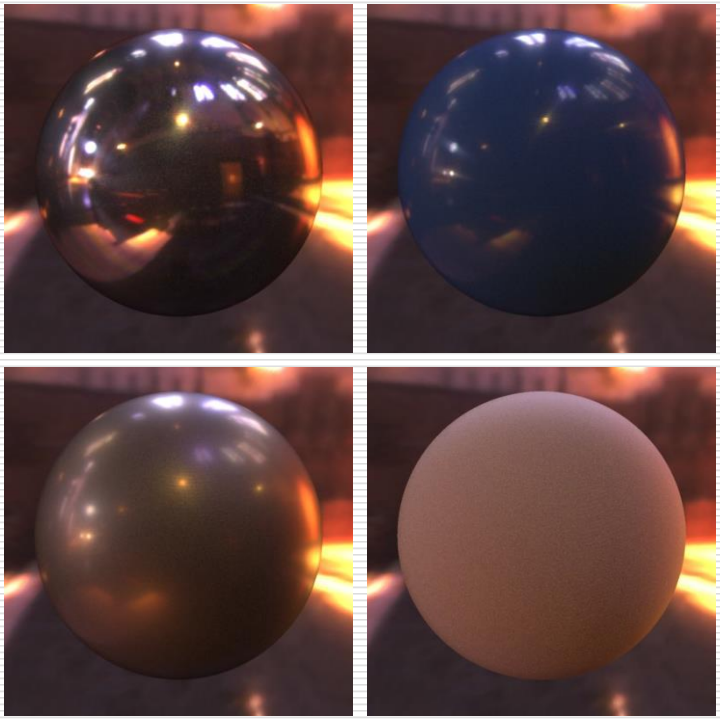
Minerva head

calibration target

Visual Appearance

BRDF (4D)

- No spatially varying
- Uniform material



Visual Appearance

Light Field (4D)

- Amount of light faring in every direction through every point in space (simplified plenoptic function)
- Fixed lighting condition and variable view direction
- Spatially varying
- Image-based rendering (no geometry)

Surface Reflectance Field (4D)

- Fixed view position and variable light direction
- Spatially varying
- Image-based relighting **(RTI)**
- Implicit geometry

Visual Appearance: how to use?

BSSRDF and BRDF

Model-based rendering

- Explicit geometry
- Modeling or acquisition of the appearance
- Global illumination algorithm
- More precise but computational heavy

Light Field and Reflectance Field

Image based rendering

- Set of photos (“interpolation”)
- No geometry or “implicit” geometry
- Realistic rendering but trade-off between data and precision

What is color?

Color is light! So how do we represent it?

- **Apparent color**
  - No lighting effects, no moving highlights
- **Unshaded texture**
  - Removal of shading & highlights
- **Spatially varying reflection properties** (Bidirectional Reflection Distribution Function, **BRDF**)
  - Relightable representation of the real object interaction with light

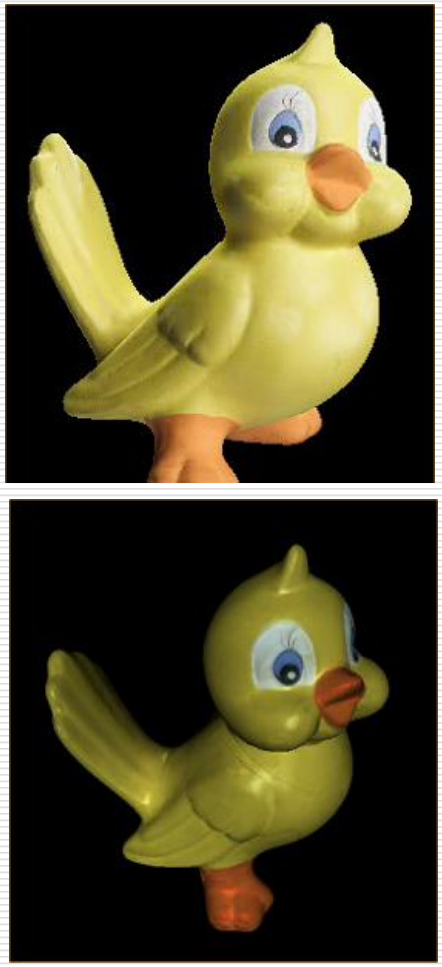


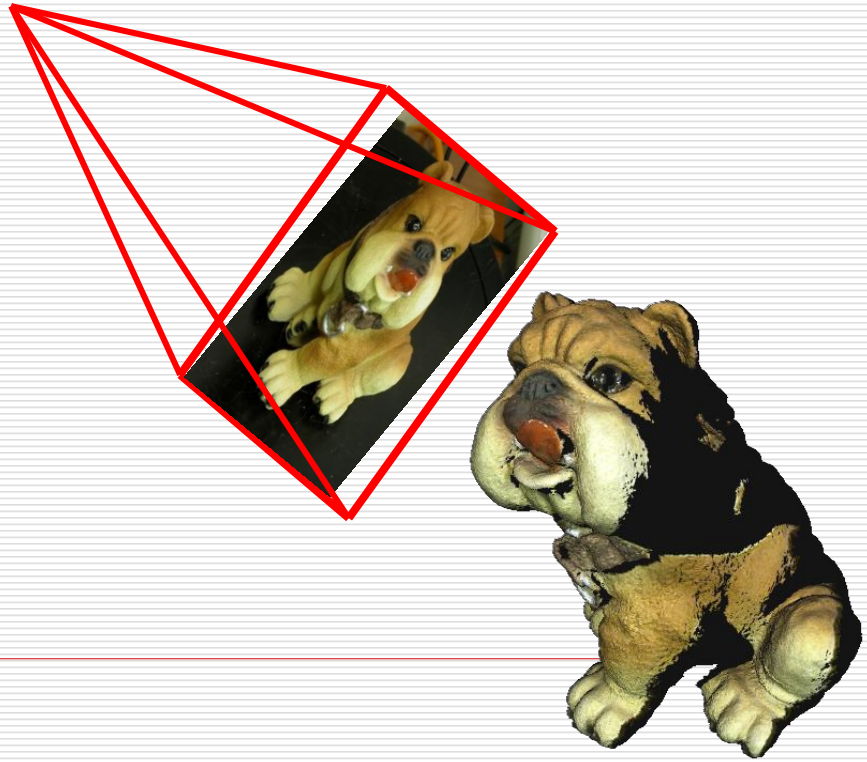
Image by MPI (Lensch, Goesele)

An alternative solution: color projection

Alternatively, we can start from a set of photos covering the surface of the object. In a photo, color information is stored according to optical laws of perspective ...

If camera parameters can be recovered, it is possible to project back the information onto the geometry

Simple and effective...

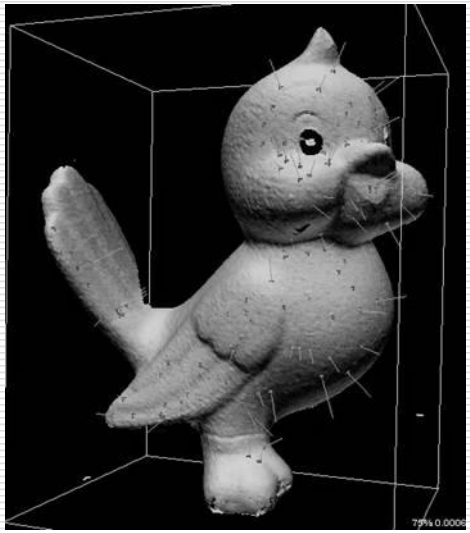


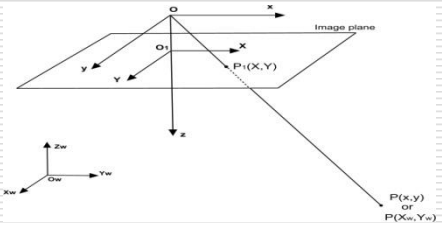
Texture building from photos: Input data

- A complete 3D model
- A set of photos
- Registration info
  (camera data)

From scanner

(Manual) Registration





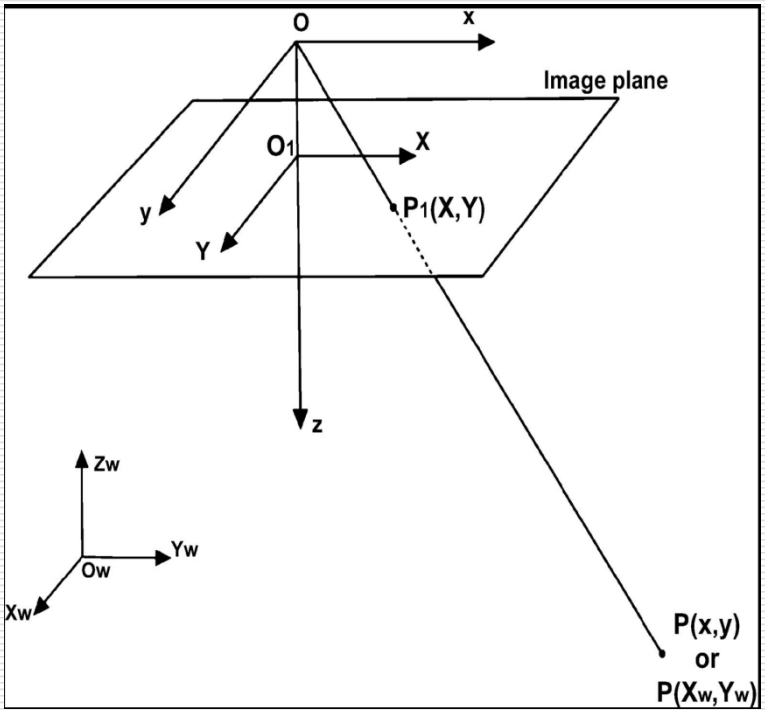
- Position
- Orientation
- Focus distance

.....

Registration info: parameters estimation

Intrinsic and **extrinsic** parameters

- Extrinsic parameters: rotation matrix and translation vector
- Intrinsic parameters: focal length, lens distortion…



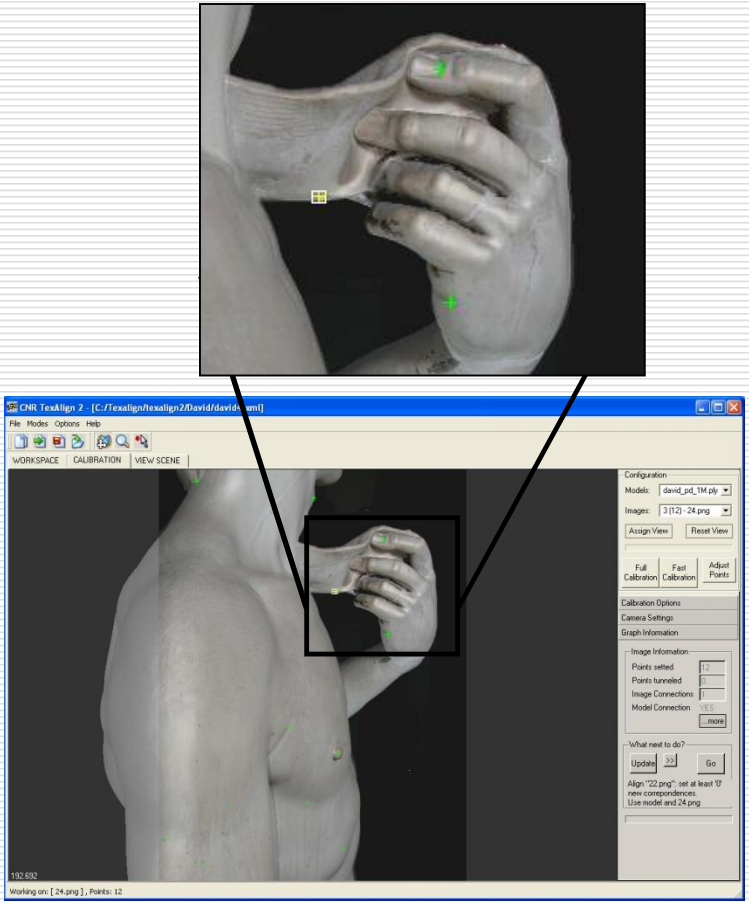
Parameters estimation using correspondences

Parameters estimation:

- Setting of some correspondences between image and geometry
- Minimization of error function

Different algorithms and implementations:

- TSAI (old faithful)
- GARCIA (fast but need good start)
- intel OpenCV (hard to integrate)



Minimizing user intervention in registering 2D images to 3D models

T. Franken, M. Dellepiane, F. Ganovelli, P. Cignoni, C. Montani, R. Scopigno 2005

Automatic alignment using mutual information

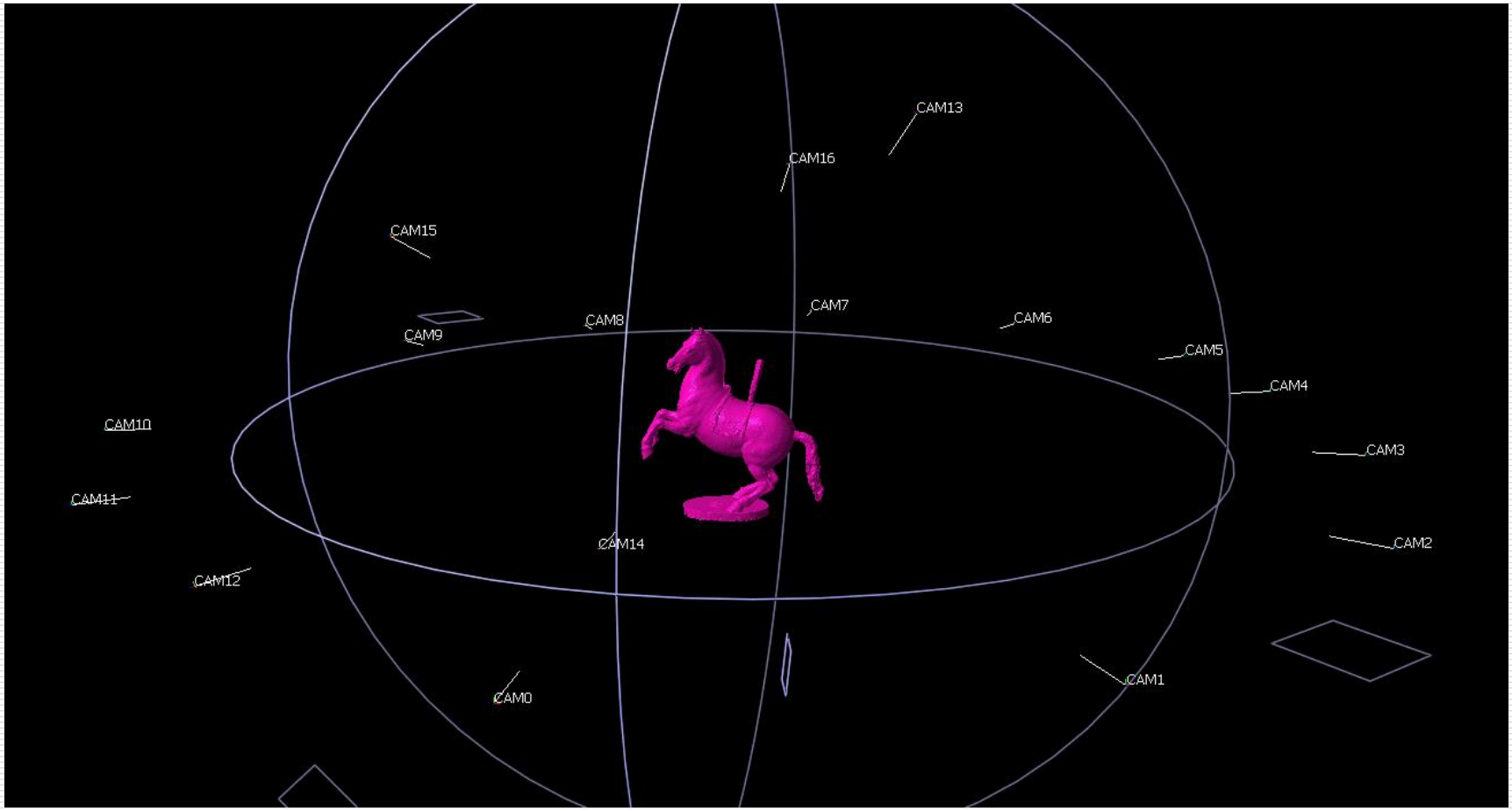
- Mutual information is used with geometric features ***correlated in some way*** to the visual appearance of the objects but *invariant* to the lighting environment.

Image registration: pros and cons

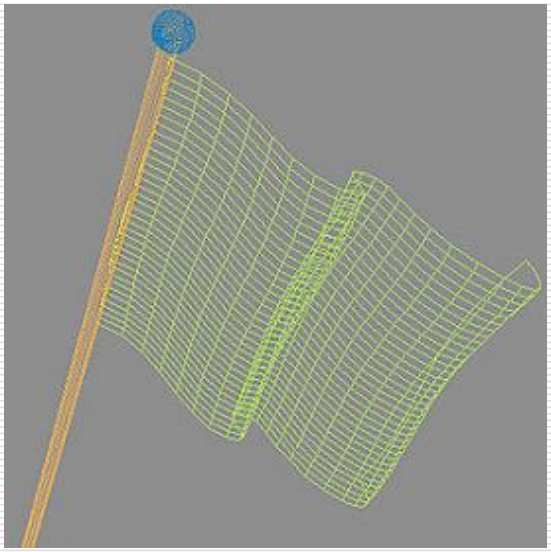
- User friendly
- Tens of images on one model
- Very flexible (from statues to buildings)
- Extensible

- Extrinsics/intrinsics
- Dependent on correspondences / Starting point
- Measure of alignment quality

3D model, photos, camera parameters… and now?



Encoding the color information: Texture mapping



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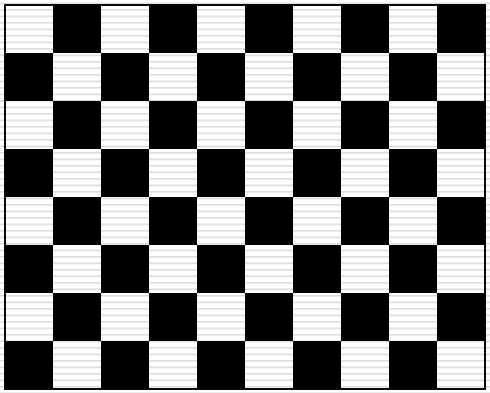

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3D geometry

RGB texture
2D

(color-map)

Encoding the color information: Texture mapping

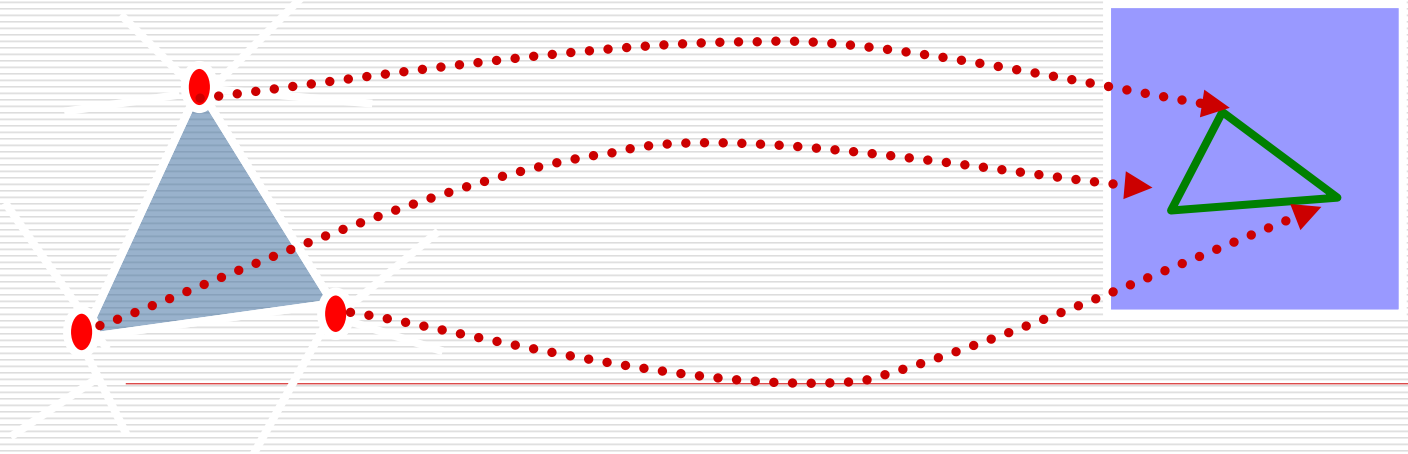
3D geometry

+

Texture: image…

=

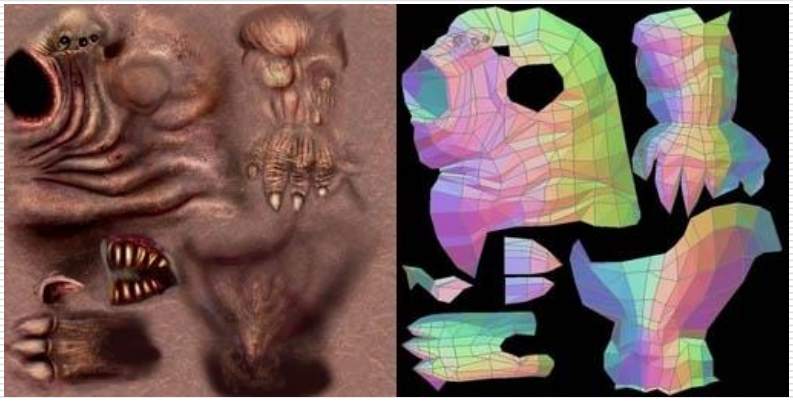
Texture mapped rendering



Encoding the color information: Texture mapping

Encoding the color information: Texture mapping

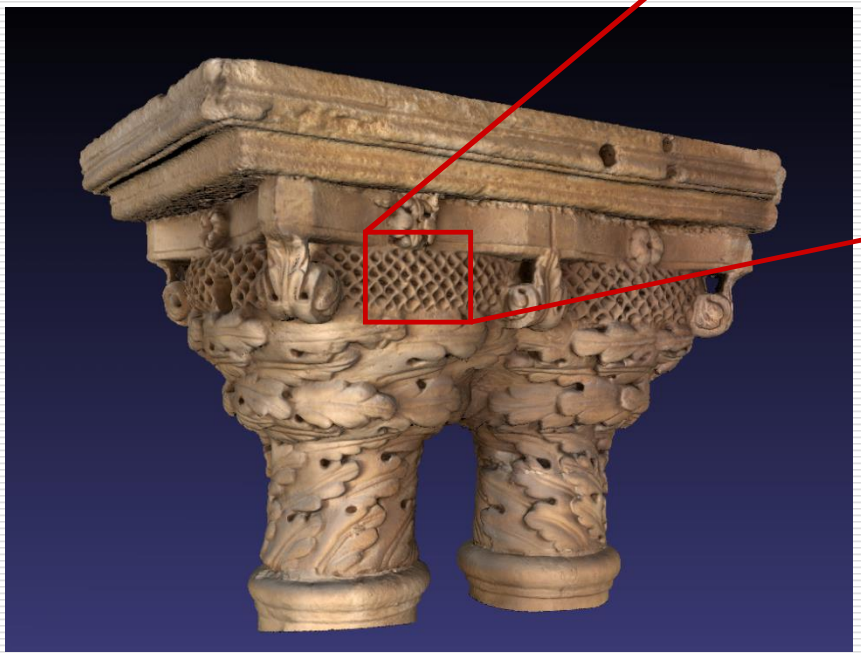
Hand made, or automatized

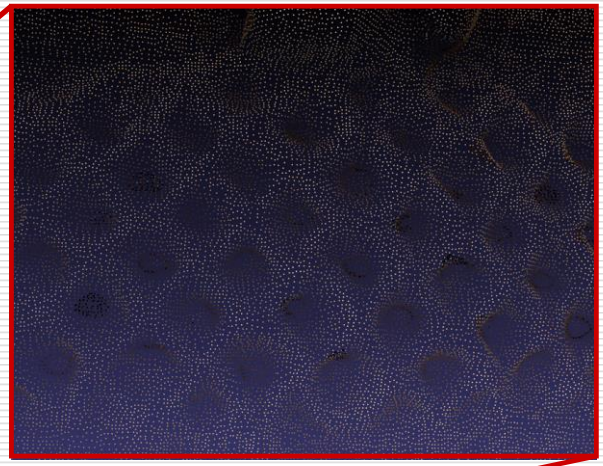


Encoding the color information: Color per vertex

A color value is assigned to each vertex of the model.

The space between points is filled via interpolation.

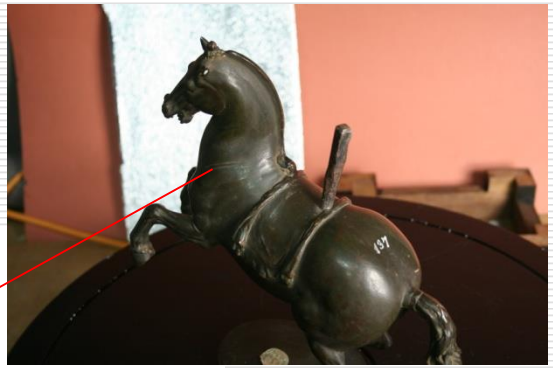


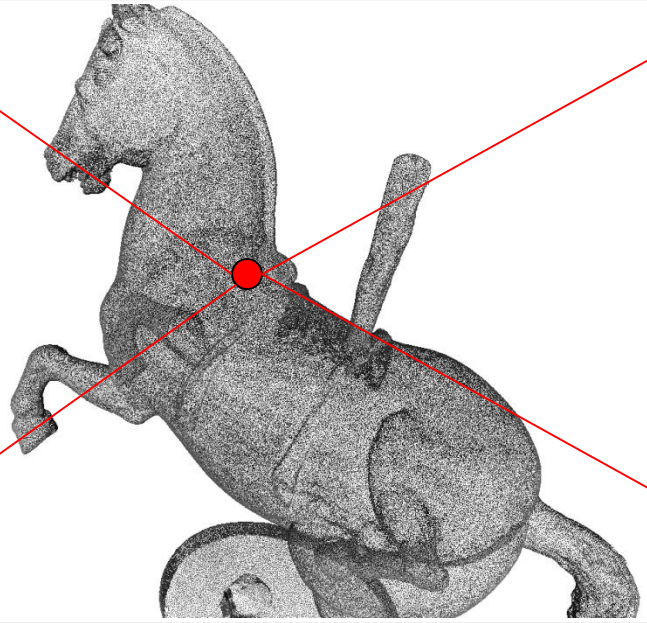


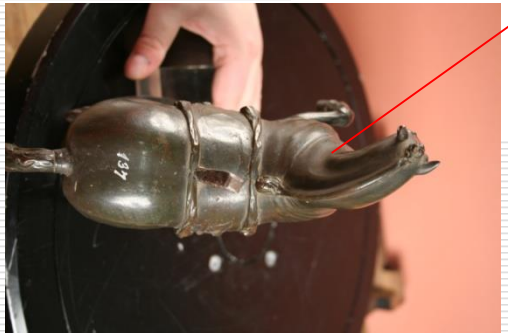
Encoding the color information

Texture Mapping	vs	Color per vertex
- Independent of geometric density		- Easy structure
- Compact 2D Structure		- Compatible with "multiresolution" or adaptive structures
- Editable, compressible, easily accessible structure		- No need for parametrization
- Parameterization		- Very dependent on geometric density
-Use with "multiresolution" or adaptive structures		- Harder to access or "boost" (for now)
-Need to pack data without losing detail		- Texture mapping is more widely used
- Blending between photos		

Mapping the color information







Which color value?

Mapping the color: automatic texture mapping

Weaver, a tool for the generation of texture maps

- For each area, the better (orthogonal) photo is chosen
- Mesh is splitted according to the photo allocation and parametrized using perspective projection
- From photos, the used area is cut and packed in the texture
- Color discordances on borders are corrected

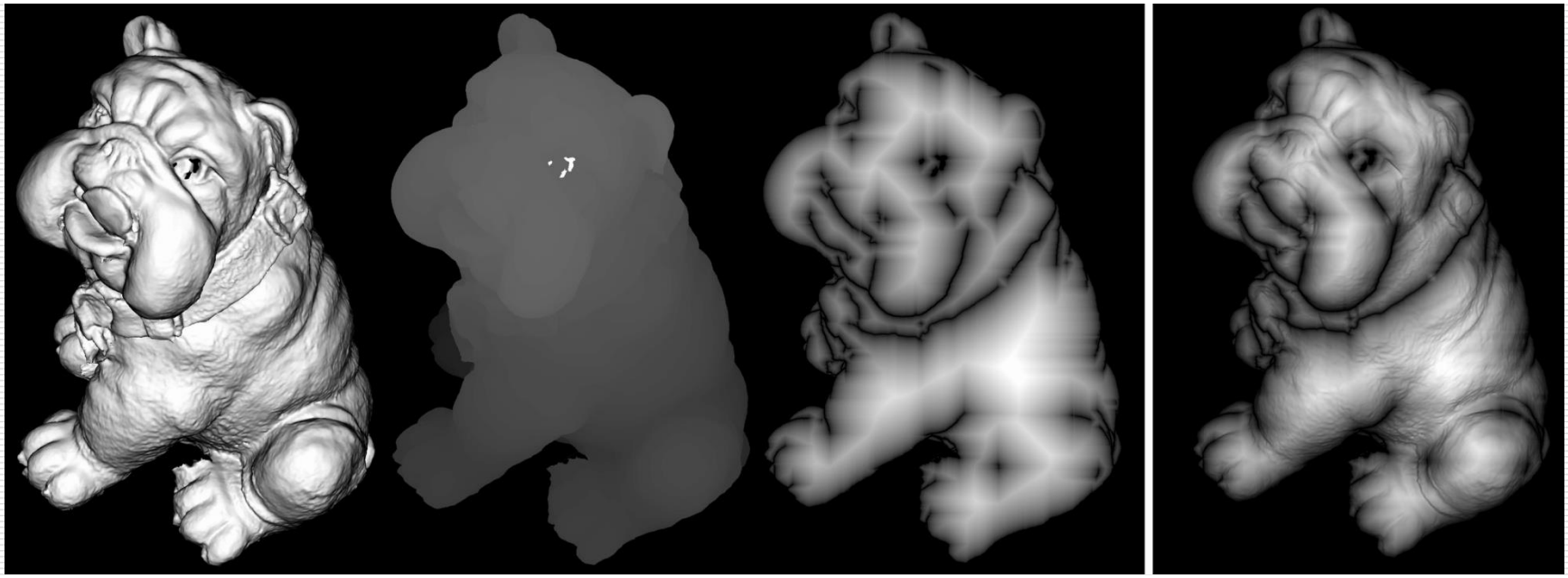
Reconstructing Textured Meshes From Multiple Range RGB Maps

M. Callieri, P. Cignoni, and R. Scopigno 2002

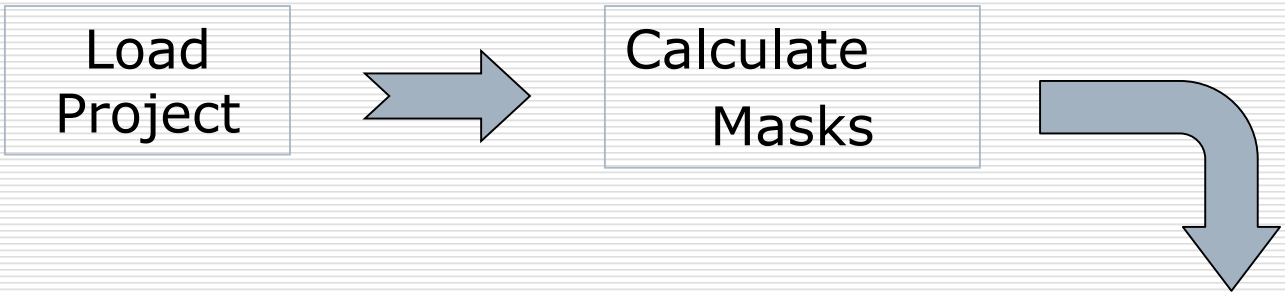
Mapping the color: masked photo blending

For each image, a set of quality masks is calculated.

Angle Mask	Depth Mask	Border Mask	Final Mask



Mapping the color: masked photo blending



For each vertex:

- Load all the images (with masks) which map on it
- Assign a color value as a weighted sum of all contributions

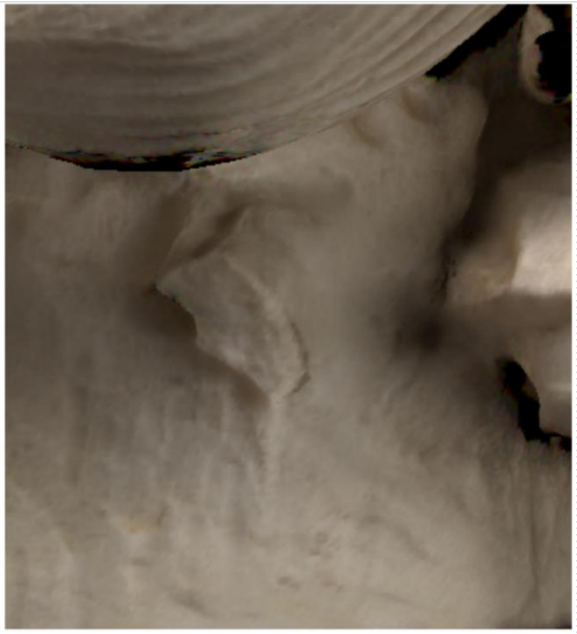
Save Model!

This can be done Out of Core!

Masked photo blending

M. Callieri, P. Cignoni, M. Corsini and R. Scopigno

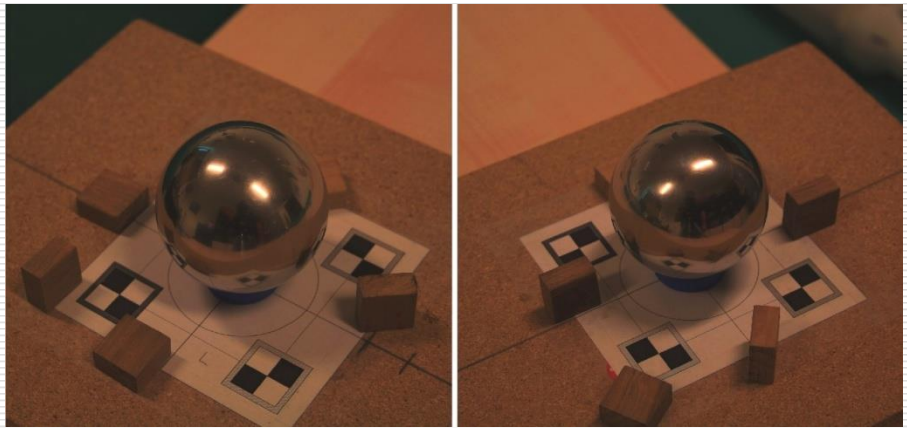
Color projection: open issues



The quality of color depends mainly on:

- the original photo set (shadows, highlights, uneven lighting, bad coverage)
- the quality of image registration

Color projection: controlling the light environment



Use an acquisition device to estimate the lights in the scene.

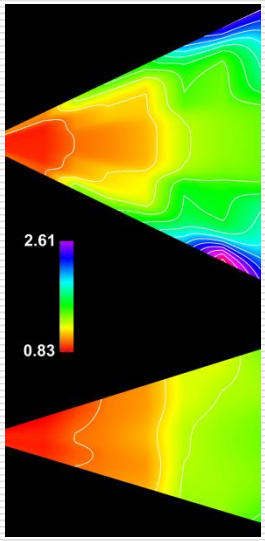
Stereo light probe

M. Corsini et al. 2008

"Calibrate" a light source to correct image artifacts before and during projection

Flash lighting space sampling

M. Dellepiane et al. 2009



MeshLab in full color

Image Alignment

Tool image registration

https://www.youtube.com/watch?v=T7gAuI-LQ2w&t=50s

MeshLab in full color

Color projection

Filters->Camera->Project active rasters to current mesh

Usage:

1) Apply

Color per vertex

or

Texture if you already have a parametrization

MeshLab in full color

Parameterization

Filters->Texture-> Parameterization + Texturing from images

Usage:

1) Define texture name and resolution
2) Apply
3) Save model with texture

Color projection: wrap up

Big issues in color projection

- Photo shooting (lights setup, surface coverage)
- Material estimation
- Image registration (semi-automatic)
- Color encoding
- Color projection
- Visualization

Pseudo-conclusion: the approach depends mainly on the object and the application

Next in line…

Next lesson:

- Projects

Contacts:

Matteo Dellepiane

c/o ISTI-CNR Via G. Moruzzi 1

56124 Pisa (PI)

Tel. 0503152925

E-Mail: dellepiane@isti.cnr.it

Personal website: http://vcg.isti.cnr.it/~dellepiane/

VCG website: http://vcg.isti.cnr.it