Il colore: acquisizione e visualizzazione

Lezione 17: 11 Maggio 2012

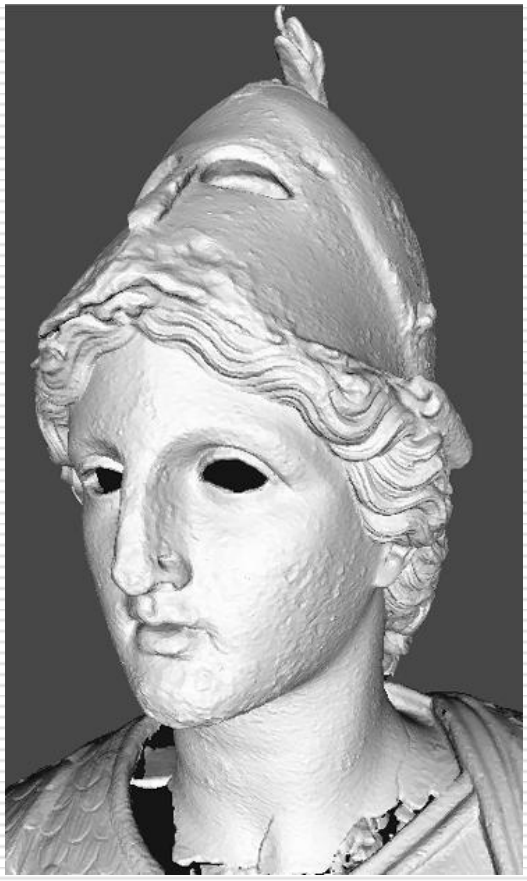
The importance of color information

Precision vs. Perception

3D scanned geometry

Photo

Color and appearance



Pure geometry

“Pure” color

Rendering of material properties

What is color?

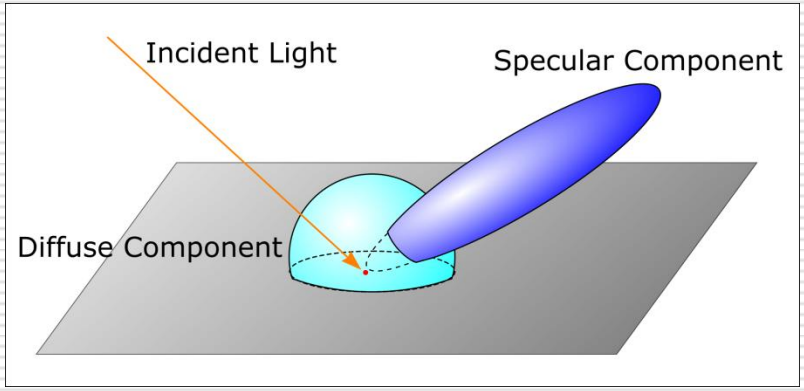
Color is light! So how do we represent it?

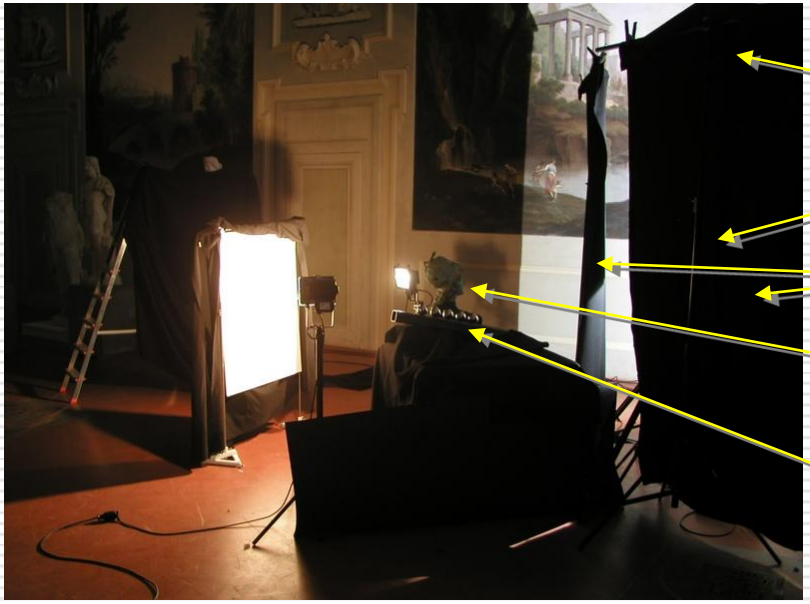
- **Apparent color**
  - No lighting effects, no moving highlights
- **Unshaded texture**
  - Removal of shading & highlights
- **Spatially varying reflection properties** (Bidirectional Reflection Distribution Function, **BRDF**)
  - Relightable representation of the real object interaction with light

Image by MPI (Lensch, Goesele)

BRDF acquisition

BRDF(θi,Φi,θo,Φo,u,v)





light source

camera

black felt

Minerva head

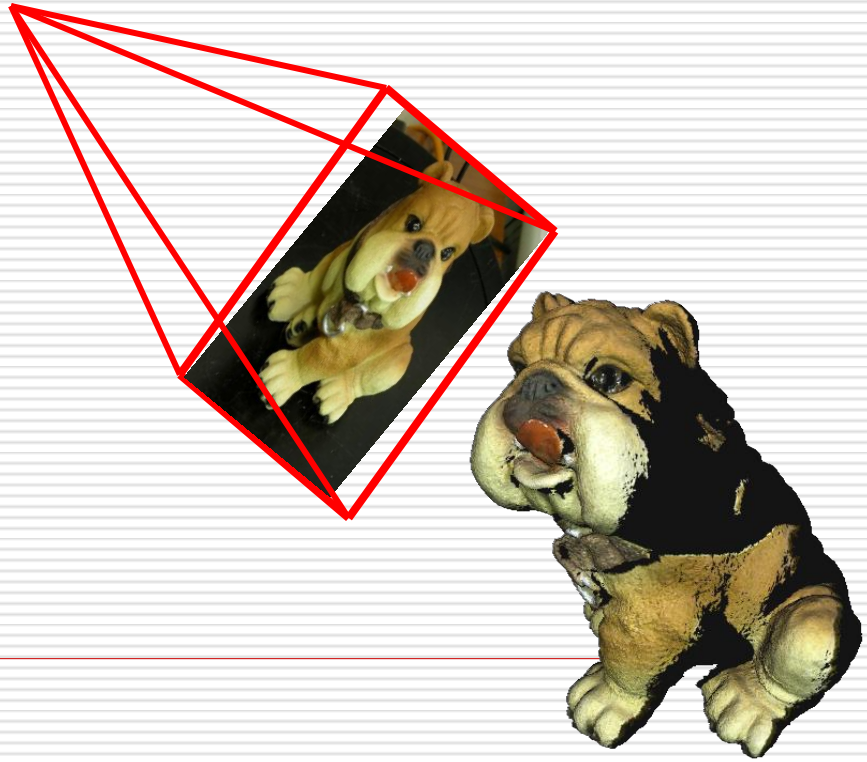
calibration target

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...

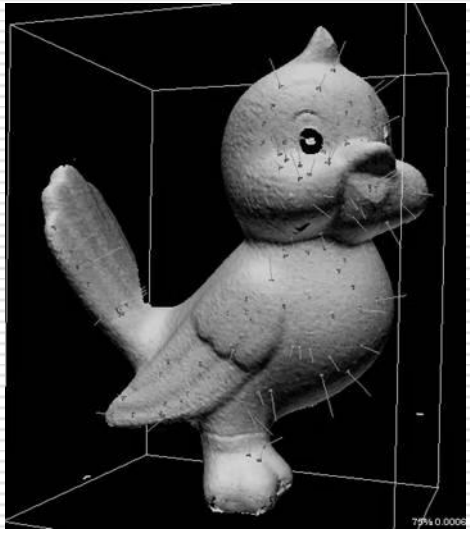


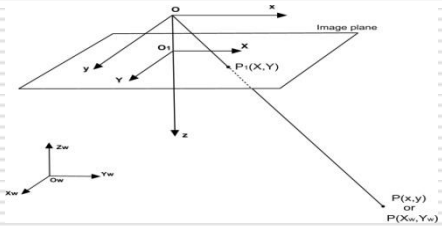
Texture building from photos: Input data

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

From scanner

(Manual) Registration





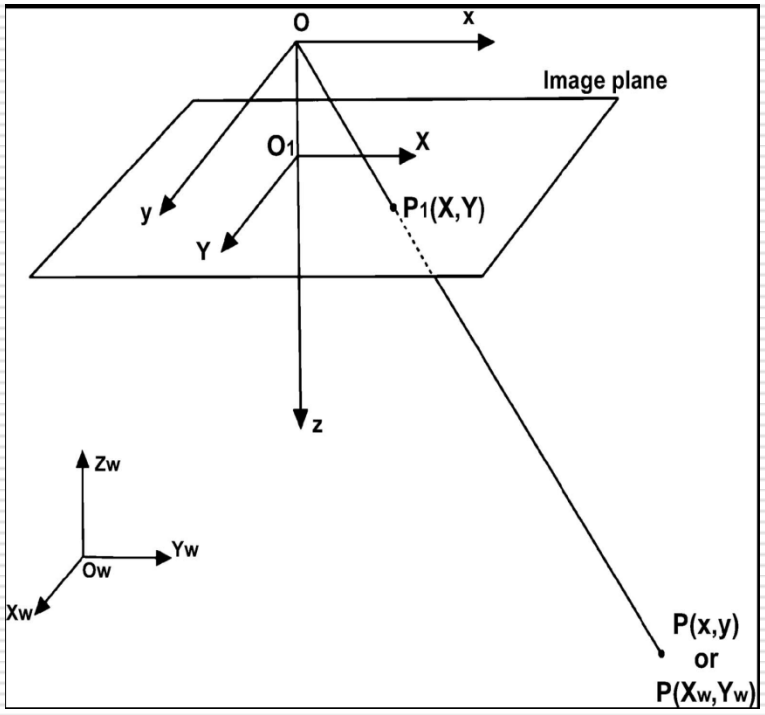
- Position
- Orientation
- Focus distance

.....

Registration info: parameters estimation

Intrinsic and **extrinsic** parameters

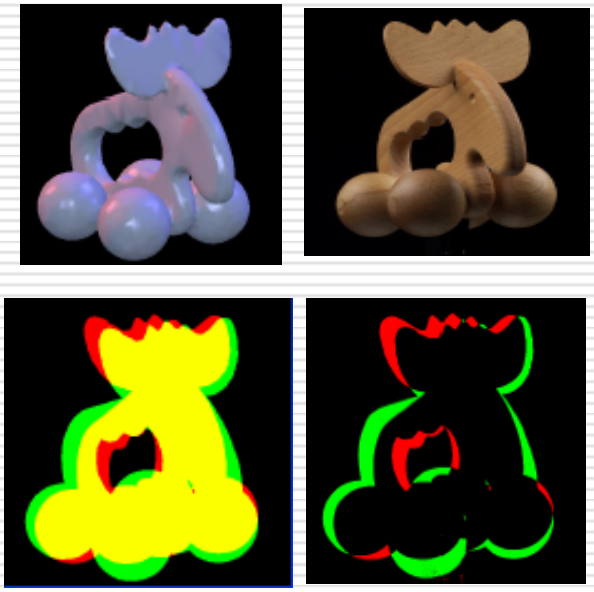
- Extrinsic parameters: rotation matrix and translation vector
- Intrinsic parameters: focal length, lens distortion…



Automatic parameters estimation

Automatic camera computation via silhouette matching

- Compute silhouette on image
- Render the 3D model
- Compute error as render-silhouette image difference
- Greedy iteration, by small rotations, until silhouette matching error is below a threshold



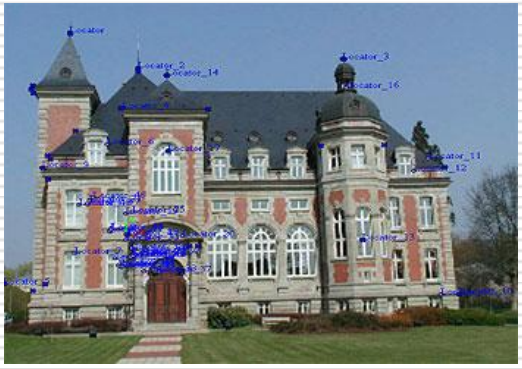
Limitations:

all object visible in each image ==> just small objects!
hard or impossible to generate silhouette

Automated Texture Registration and Stitching for Real World Models
Lensch et al, Pacific Graphics 2000

Estimation using photogrammetry tools

Photogrammetry tools do estimate the camera parameters and can be used to recover intrinsics and extrinsics to project color on a 3D model. Many tools can as well do the entire texturing process, for small models



http://imagemodeler.realviz.com

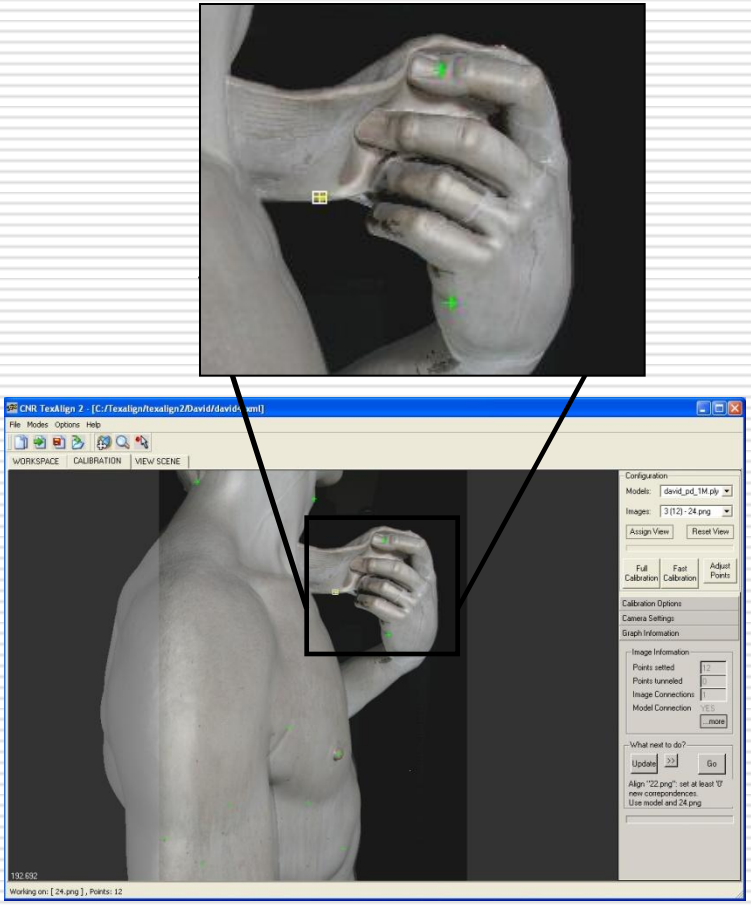
Parameters estimation using correspondences

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

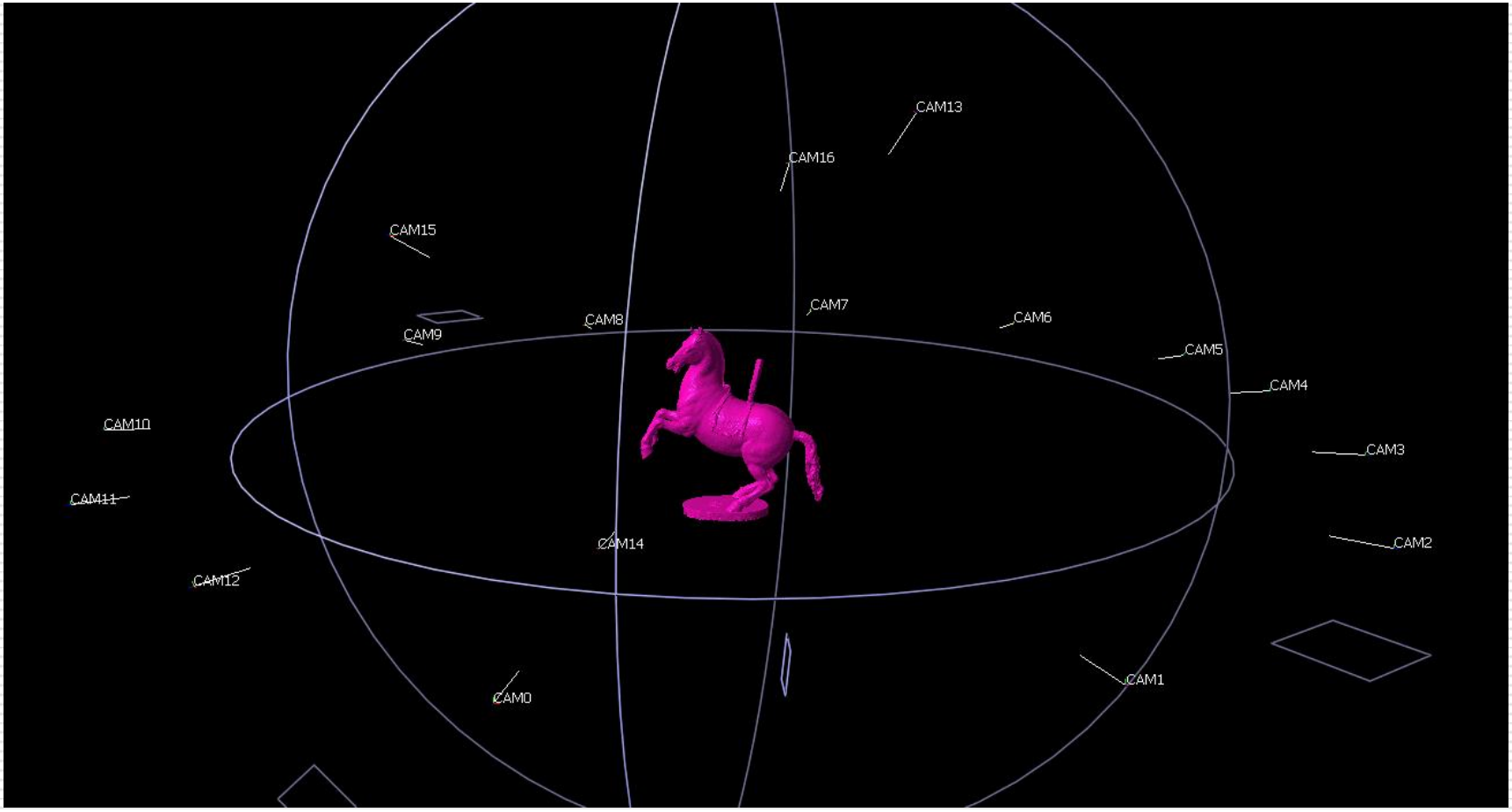
- Mutual information is used with geometric features ***correlated in some way*** to the visual appearance of the objects but *invariant* to the lighting environment.

Image registration: pros and cons

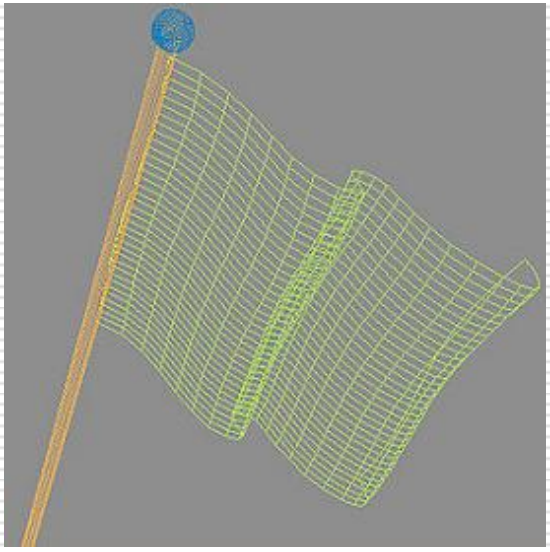
- User friendly
- Tens of images on one model
- Very flexible (from statues to buildings)
- Extensible

- 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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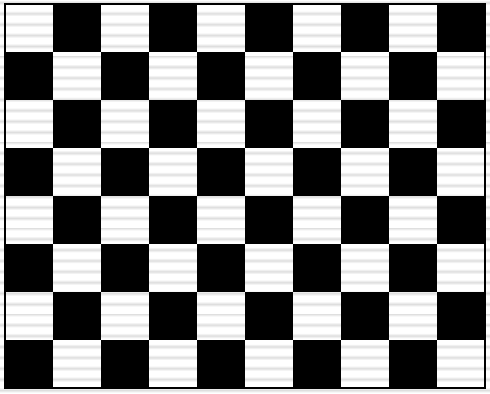

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3D geometry

RGB texture
2D

(color-map)

Encoding the color information: Texture mapping

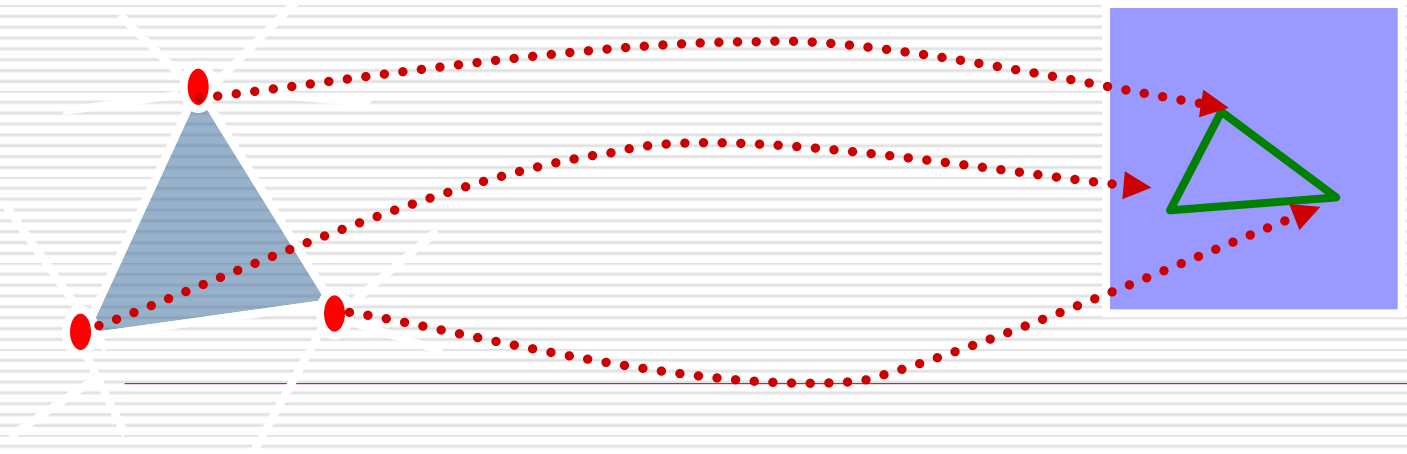
3D geometry

+

Texture: image…

=

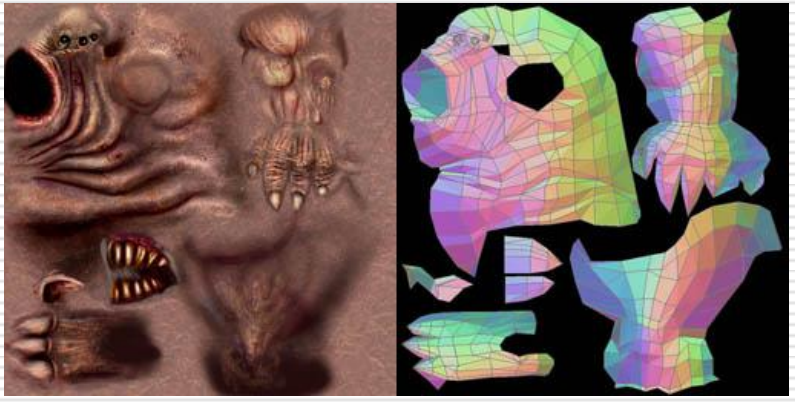
Texture mapped rendering



Encoding the color information: Texture mapping

Encoding the color information: Texture mapping

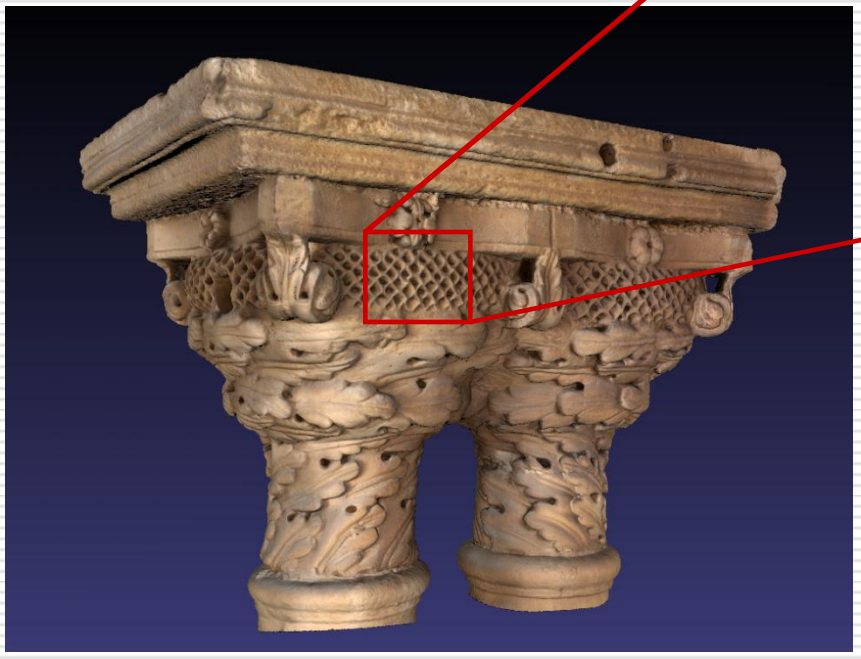
Hand made, or automatized

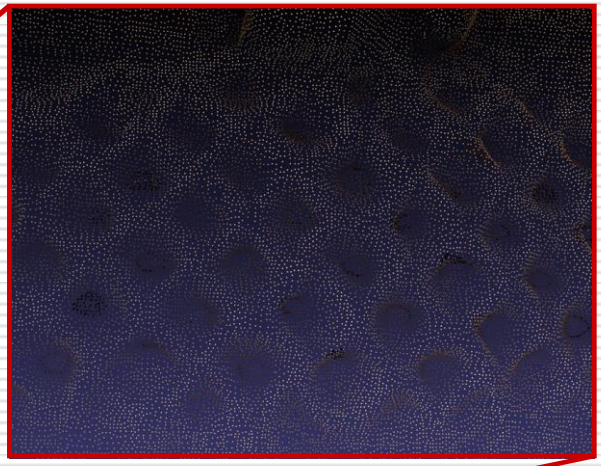


Encoding the color information: Color per vertex

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

The space between points is filled via interpolation.

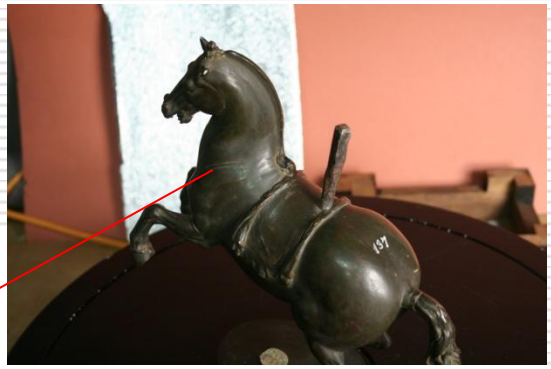


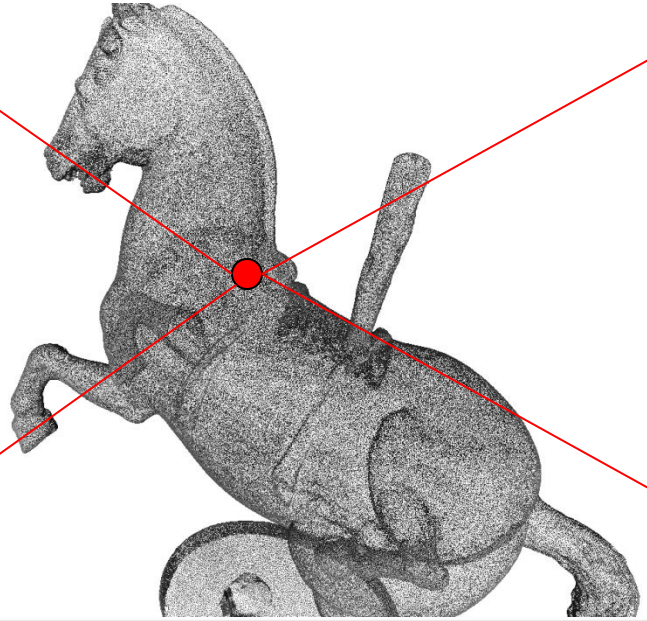


Encoding the color information

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

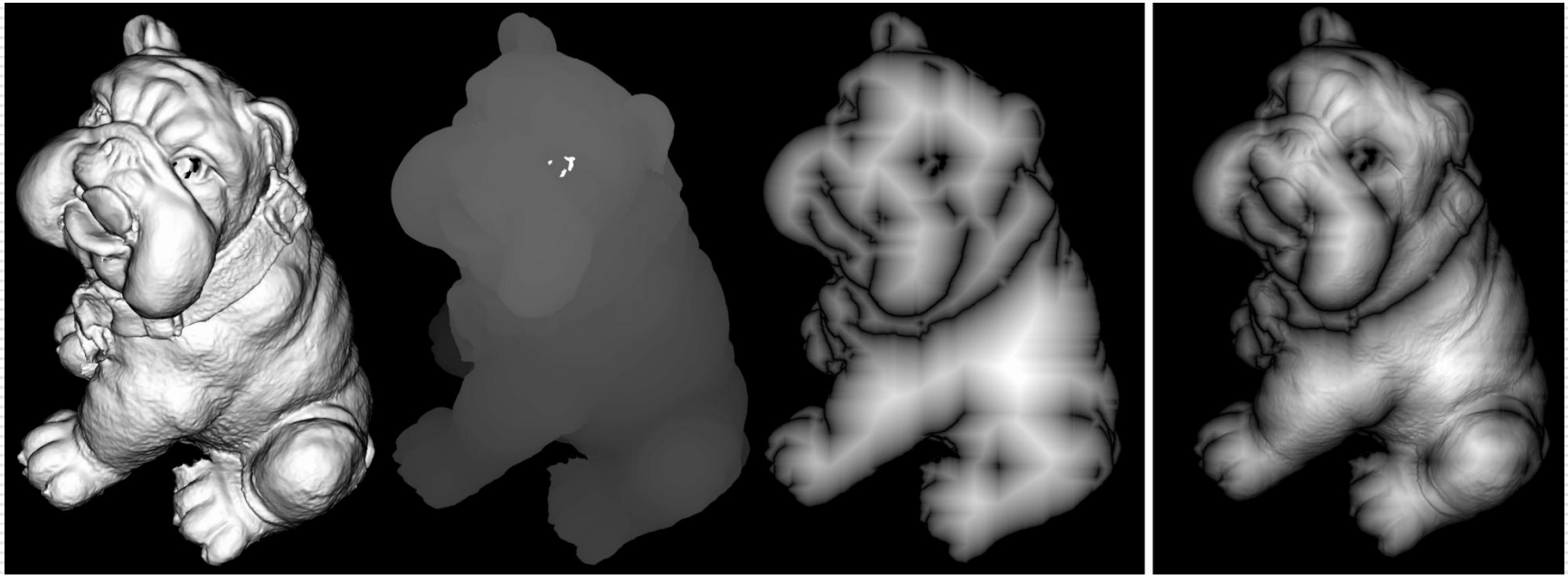
Reconstructing Textured Meshes From Multiple Range RGB Maps

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

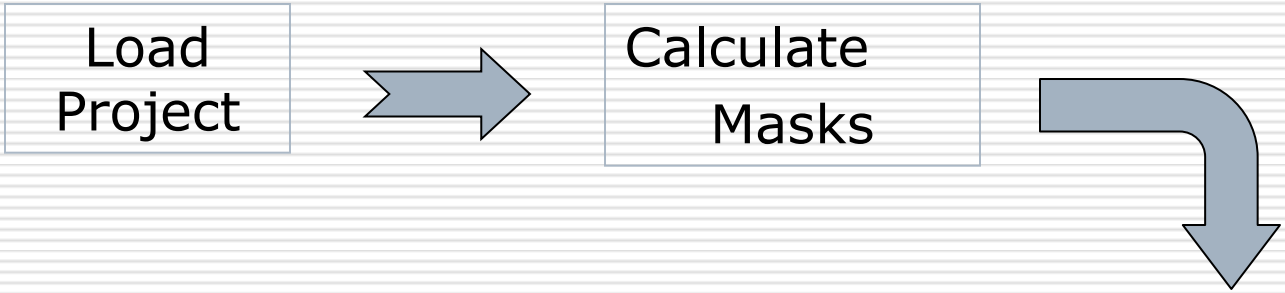
Mapping the color: masked photo blending

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

Angle Mask	Depth Mask	Border Mask	Final Mask



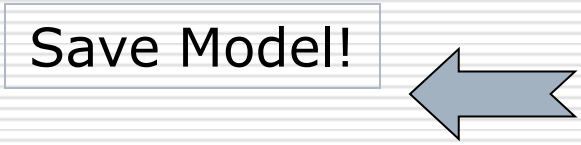
Mapping the color: masked photo blending



For each vertex:

-Load all the images (with masks) which map on it

- Assign a color value as a weighted sum of all contributions

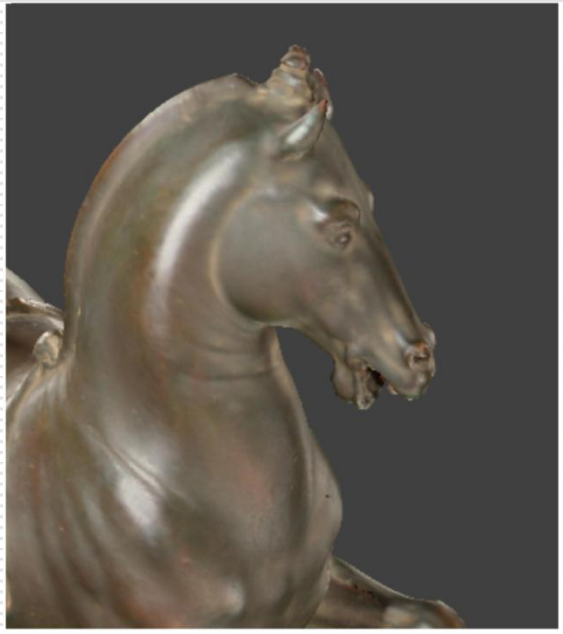


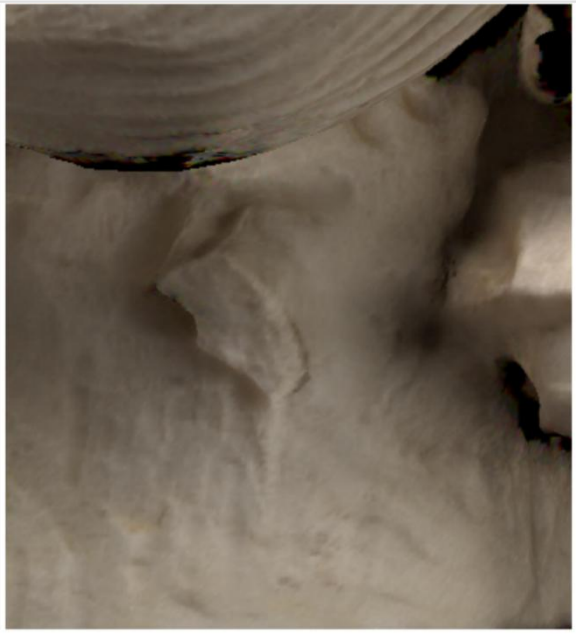
This can be done Out of Core!

Masked photo blending

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

Color projection: open issues

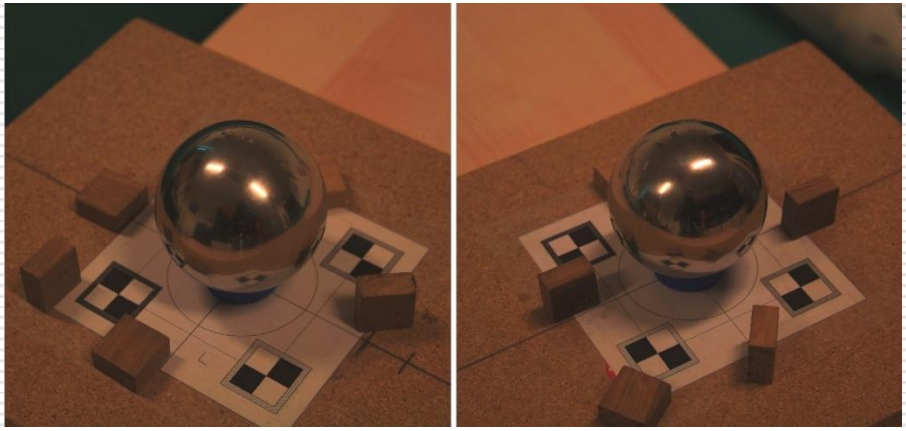




The quality of color depends mainly on:

- 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.

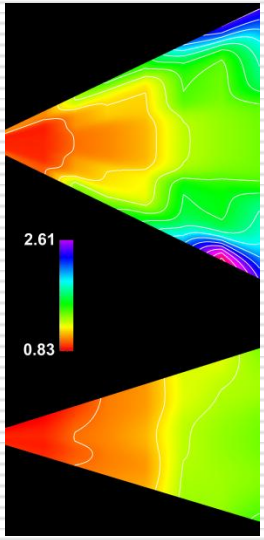
Stereo light probe

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

Filters->Camera->Image registration: Mutual information

Usage:

1) Get Shot
2) Apply

Note: Focal length issue

Coming (not) soon:

Use of correspondences/hybrid method (Sottile et al 2010)

MeshLab in full color

Color projection

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

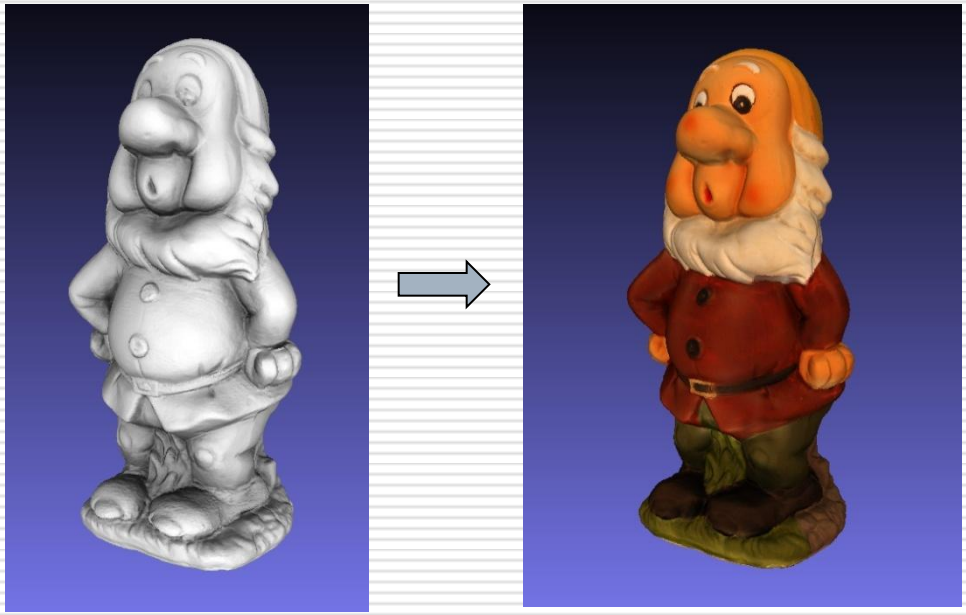
Usage:

1) Apply

Color per vertex

or

Texture if you already have a parametrization



MeshLab in full color

Parameterization

Filters->Texture-> Parameterization + Texturingfrom images

Usage:

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

Note: will be present in the official release

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:

- 3D Imagery (with Marco Callieri)

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