Mathematicians helping Art Historians and Art Conservators

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Math and Art Conservation

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Art Historians and Art Conservators





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features work in collaboration with North Carolina Museum of Art

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Rachel Yin, Bruno Cornelis, Jianfeng Lu, ID (and collaborators)



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First: two examples of how Mathematics

helped

Art historians and conservators

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Massimo Fornasier : Fresco reconstruction Eremitani, Padua, Italy.



March 11, 1944:

Allied bombing of Eremitani Church in Padua (Italy)





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frescoes by Andrea Mantegna et al. in Ovetari Chapel – destroyed

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Fresco fragments stabilized

August 1992: fragments all collected at Villa Nazionale di Strà.

fragments cleaned, consolidated and catalogued.

Photographed (1995-1997) digitized on 38 CD-ROMs







Difficulties in traditional restoration

Fragments: 3-4 cm2, no context.

Surface of origin : > 500 m2 Fragments cover in total maybe 77 m2 ... Few contiguous fragments

Each fragment: unknown position unknown orientation as well



Digital images

Digital Image: collection of bright (or colored) points distributed on a rectangular surface



Digital images

18	28	127	43	32	75	83
12	123	12	23	12	23	11
11	94	13	12	54	32	123
10	72	12	144	100	18	80
97	12	34	72	121	54	92
01	78	63	32	65	89	192
	18 12 11 10 97 01	 18 28 12 123 11 94 10 72 77 12 01 78 	18281271212312119413107212971234017863	182812743121231223119413121072121449712347201786332	18281274332121231223121194131254107212144100971234721210178633265	18281274332751212312231223119413125432107212144100189712347212154017863326589



Comparison of images

↓ to decide whether two digital images are identical, we need check only whether the numerical values coincide!

But ... although two tables of numbers may represent the same picture, they do NOT coincide exactly, usually; numerical values will be close but not identical.



Existing gray level images of the frescoes

we need "only" read the numerical representation of each fragment, and determine which piece of the 1920 photo is most similar.

Unfortunately it is not that simple ... the fragments are ROTATED w.r.t. their original situation!!



Image rotation

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	95	0	0	0	0
0	0	49	50	65	82	103	0	0	0	0	0	57	93	101	0	0	0
0	0	51	68	73	93	93	0	0	0	0	56	68	88	97	106	0	0
0	0	62	85	96	116	104	0	0	0	49	49	65	85	116	115	116	0
0	0	68	97	121	128	115	0	0	0	0	51	70	91	116	125	0	0
0	0	83	98	123	123	112	0	0	0	0	0	65	90	111	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	78	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



Images can be decomposed into "circular harmonics",i.e. building blocks that perform particularly well under rotations.



Example of decomposition

If Im is the image and I1, I2, I3 ... are the circular hamonics then there exist numbers a1, a2, a3 ... such that

Im = a1 I1 + a2 I2 + a3 I3





Simplifying rotations

If Rot-Im is the rotated image of Im and if I1, I2, I3 ... are the circular harmonics then there exist numbers r1, r2, r3 ... that depend only on the rotation such that

Rot-Im = r1 a1 I1 + r2 a2 I2 + r3 a3 I3 + ...



Simplifying the rotations

Therefore, to decide whether an image is a rotated version of another, it is sufficient to
decompose both in circular harmonics
check whether their coefficients show the right proportionalities

Decomposition into the circular harmonics and checking of these relations can be done very fast!



The Mantegna Project



- Università degli Studi di Padova
- Soprintendenza ai Beni Storici ed Artistici del Veneto
- Curia Vescovile di Padova
- Fondazione Cassa di Risparmio di Padova e Rovigo



The MantLab



October 22 2001: start of MantLab, installed in the heart of city of Padua, hosting researchers, technicians, art professionals, students and volunteers.



Work Procedure

- Fragment selection: Extracting fragments from the digital catalogue
- Numerical computation:

local computer cluster searches fragments on the frescoes; returns list of possible matches

 Visual analysis: Final decision by human operator (visually)







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Some numbers:

- Total number of fragments: 80735
- Total surface of fragments: 77.47 sq. m
- Most frequent dimensions: 5-6 sq. cm (about 2.5 x 2.5 cm)
- Original surface of frescoes: 700-800 sq. m



Localized fragments on "S.Giacomo e l' Imperat."

- N. Fragments: ≈ 800
- Surf. scene: 11.5 sq.m.
- Density: 69 fr/sq.m.


Detected fragments on "Andata al martirio"

N. Fragements: ≈ 440
Surf. scene: 11.5 sq.m.
Density: 39 fr/sq.m.



Cesare Brandi, 1947

(paraphrased)

In many cases, even a modest isolated color fragment enables the conservator to color a whole region of the picture nearby: in some sense its information can be diffused throughout.

























First: two examples of how Mathematics

helped

Art historians and conservators

Rick Johnson: Automatic thread counting for paintings on canvas.

























Second half of this presentation:

features work in collaboration with North Carolina Museum of Art

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Peruzzi Altarpiece



Giotto di Bondone "Peruzzi Altarpiece" circa 1310-15

A less famous altarpiece

14th century, from Fabriano in Marche, Italy Francescuccio Ghissi

Less famous than Giotto ...

.. still pretty fabulous for its town and church!



















One missing panel ...

Reconstruction by Charlotte Caspers (who had collaborated with ID before)

Charlotte Caspers - Reconstructions



Charlotte Caspers - Reconstructions





Reconstruction of 9th Ghissi panel



Reconstruction of 9th Ghissi panel










Ghissi altarpiece



New panel: bright, shiny

New panel: bright, shiny

-

will give exhibition visitors a lively impression of the 14th century experience

New panel: bright, shiny

will give exhibition visitors a lively impression of the 14th century experience

but ... real 14th century panels will look dull in comparison



Preparing for the exhibition (Fall '16)

From detailed image analysis of the old panels, get realistic idea of

- crack "map"
- pigment fading and darkening

with this information, prepare a virtual "aged" copy of new 9th panel

Preparing for the exhibition (Fall '16)

From detailed image analysis of the old panels, get realistic idea of

- crack "map"
- pigment fading and darkening

 also use this to virtually "rejuvenate" the old panels!

Ghent Altarpiece 15th century, Flemish Jan Van Eyck





















Cradle removal project

To inspect cracks: X-ray very useful

Strange horizontal and vertical stripes ..

Cause?

Cradling





Cradling





Cradling

Develop image processing algorithms to remove cradling artifacts from X-rays:

Challenging! Nothing is truly horizontal or vertical; not quite uniform shading; woodgrain from cradle but also in panel

Cradle removal (virtually)



Cradling removal (virtually)



our algorithm

professional art conservator using Photoshop

Cradling removal (virtually)

- hope: develop user-friendly software package
- make available in open source, so it can be adapted by others for specific problems, and spur more collaborations between art conservators and signal processing groups

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with, of course, the help of LOTS of (applied) math!

Platypus workshop



NCMA July 18, 2015





