Image analysis techniques to help study masterwork paintings???

Ingrid Daubechies
(cheerleader)

and many others (who really did the work)
Earlier work of image analysis groups on paintings:

* distinguishing copy from original
  (E. Brevdo, C. Caspers, S. Hughes, S. Jafarpour, G. Polatkan, ID)

* Lady 6mm under: Face hidden under the Patch of Grass
  (A. Brasoveanu, B. Cornelis, J. Dik, A. Dooms, S. Hughes, K. Janssen, ID)

* Underdrawing characterization in Goossen van der Weyden
  (R. Calderbank, S. Jafarpour, M. Martens, J. Wolff, ID)
DISTINGUISHING A COPY FROM AN ORIGINAL

* IP4AI workshops with Van Gogh Museum (Amsterdam), Kröller-Müller Museum (Arnhem), MoMA (New York)

* First workshop challenge: distinguish, by IP techniques, VG from others (copies, fakes, early inspirations)

* NOVA challenge
Analysis method: study images at different scales

In particular:

- determine image content at different scales

- which information “lives” at different scales?

- find local hierarchical relationships governing information at these scales
Determine information at different scales
Determine information at different scales
Determine information at different scales

and find the difference

blur
Determine information at different Scales

Difference = A - B
Determine information at different Scales

\[
\text{Difference} = A - B
\]
Determine information at different Scales
Stylistic Analysis

- Tried to characterize Van Gogh vs. others

this separated other artists from Van Gogh.
Stylistic Analysis

- Tried to characterize Van Gogh vs. others

this failed on paintings that imitated VG's style
From Last Year

- Eric Postma's earlier work:
  - “copies have more wavelets in their decomposition”
From Last Year

- Eric Postma's earlier work:
  - “copies have more wavelets in their decomposition”
- More wavelets means more high scale wavelets
From Last Year

• Eric Postma's earlier work:
  ◦ “copies have more wavelets in their decomposition”

• More wavelets means more high scale wavelets

• Check for finest scales!
From Last Year

• In paintings that are copies (regardless of who does the copying) or that are more “hesitating”, there is a much larger concentration in the finest scales.
The NOVA Challenge

This allowed us to distinguish a copy by Charlotte Caspers from 5 original Van Goghs.
The NOVA Challenge

- This allowed us to distinguish a copy by Charlotte Caspers from 5 original Van Goghs.
What is Fine Scale Detail?
Work on Expanded Dataset

- Measured fine scale detail on this year’s expanded dataset.
Work on Expanded Dataset

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- ALL of the newly added 21 paintings are marked as hesitant.
Work on Expanded Dataset

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- ALL of the newly added 21 paintings are marked as hesitant.

WHY?
**Sharpness**

- Eric Postma recently purchased a new slide scanner, on which the new images were scanned.
- New images are crisper than our old ones.
Effect of Blur on Fine Scale Detail

Blurry pictures have less fine scale detail.
Measuring Blur

Measured blur quantitatively in previous sets of paintings examined. For the NOVA 6:

The copy is by far the least blurry. This unfairly helped us detect it...
A Fairer Test

Copies vs. Originals of Similar Blur
Methods to Overcome Blur

What are we trying to characterize by measuring fine scale detail amount?
Methods to Overcome Blur

- Idea: Classify different TYPES of fine scale details:
  - compositional edges that will always be present
  - wobbles
Results of Two Approaches

• Measure only weight of very finest scales:
  • Correct 87% of the time on test set.
  Does not generalize well to other copies: Does not do well on S506.

• Use more sophisticated wavelet features:
  • Correct 90% of the time on test set.
  Generalizes well to other copies:
  Classifies 87% of S506 correctly.
A Second Validation Test

- We asked Charlotte Caspers to paint a series of pairs of small paintings
- In each pair: one original
  one copy
- Different pairs painted with different brushes, paint, background, ...
A Second Validation Test
Some of the originals and copies painted by Charlotte.
Variety of Materials and Styles
Advantages of this Dataset

- Ground truth: we know which are “hesitating” copies and which are originals
- Uniform digital imaging conditions
  - Blur, lighting, etc. are same
  - High-quality direct digital scan of surface
- Variety of materials and styles
Methods of Testing

- **Known materials test:**
  - Cross-validation on all patches of all materials
  - Simulates having seen an original and a copy in these materials before.

- **Unknown materials test:**
  - Only learn from other paintings (other materials).
Second half of this presentation:

features work in collaboration with North Carolina Museum of Art

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

William Brown, Noelle Ocon, David Steel

Charlotte Caspers
Peruzzi Altarpiece

Giotto di Bondone “Peruzzi Altarpiece” circa 1310-15
A less famous altarpiece

14\textsuperscript{th} century, from Fabriano in Marche, Italy

Francescuccio Ghissi

Less famous than Giotto ..

.. still pretty fabulous for its town and church!
Ghissi altarpiece
Ghissi altarpiece
Ghissi altarpiece
Ghissi altarpiece
One missing panel ...

Reconstruction by Charlotte Caspers
  (who had collaborated with ID before)
Charlotte Caspers - Reconstructions
Charlotte Caspers - Reconstructions
Charlotte Caspers: partner in
“Copies vs. Originals” project
(can one distinguish painting style
of copyist from free-style painter?)

NOVA program (in collaboration with Van Gogh
Museum, Amsterdam, Netherlands)

ip4ai project (Princeton, Duke)
Ghissi altarpiece
Reconstruction of 9th Ghissi panel
Reconstruction of 9th Ghissi panel
Reconstruction of 9th Ghissi panel
Reconstruction of 9th Ghissi panel
Ghissi altarpiece
Reconstruction of 9th Ghissi panel

New panel: bright, shiny
Reconstruction of 9\textsuperscript{th} Ghissi panel

New panel: \textit{bright, shiny}

\rightarrow \text{will give exhibition visitors a lively impression of the 14\textsuperscript{th} century experience}
Reconstruction of 9th Ghissi panel

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 ....
Reconstruction of 9th Ghissi 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

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!
Previous experience in doing this

Ghent Altarpiece

15th century, Flemish

Jan Van Eyck
Previous experience in doing this
Previous experience in doing this
Previous experience in doing this
De Europae universali magno tempore,

Iam dei munere visu mundi

Ab urbe Romae in saecula.

Haec est urbs regia,

Aurea et salutis fontes.

In ea spatio 

Era mundo felicitas.
Cradle removal project

To inspect cracks:
X-ray very useful

Strange horizontal and vertical stripes ..

Cause?
Cradling

cradling slat perpendicular to panel wood grain
back of painted panel
direction of wood grain of panel
cradling slats in direction of panel wood grain
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
Cradling removal (virtually)

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

NCMA

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