IP4AI3: The Third International Workshop on Image Processing for Art Investigation

May 27, 2010

Museum of Modern Art, New York, NY

Table of Contents

IP4AI3 Workshop Schedule

8:30 Registration

9:00 **Opening Remarks**
Jim Coddington, Museum of Modern Art, New York

9:15 **Computer-assisted Connoisseurship: The Interdisciplinary Science of Computer Vision and Image Analysis in the Study of Art**
David Stone, University of Delaware,
David Stork, Ricoh Innovations

9:45 **Canvas Weave Match Cliques in Vincent van Gogh's Paintings**
Don H. Johnson, Rice University,
C. Richard Johnson, Jr., Cornell University,
Ella Hendriks, van Gogh Museum

10:15 Coffee Break

10:45 **Characterizing Elegance of Curves Computationally for Distinguishing Morrisseau Paintings and Imitations**
Lei Yao, Jia Li, and James Z. Wang, Penn State University

11:15 **Spatial Approaches to Digital Stylometrics**
James M. Hughes, Daniel J. Graham, Daniel N. Rockmore, Dartmouth College
Jim Coddington, Museum of Modern Art

11:45 **Underpainting Recovery with Xray Synchrotron Imaging and Image Processing**
Shannon Hughes, Anila Anitha, University of Colorado
Ingrid Daubechies, Andrei Brasoveanu, Princeton University
Joris Dik, TU Delft

12:15 Lunch Break

1:30 **A Registration and Normalization Open Source Program for Images and Photographs**
Patrick Ravine, George Eastman House International Museum of Photography & Film
Maria Helguera, Karl Baum, Rochester Institute of Technology

1:45 **Between Pigments and Pixels**
Barbara Zitova, Institute of Information Theory and Automation, Academy of Sciences, Prague , Czech Republic

Janka Hradilova, Academy of Fine Arts, Prague, Czech Republic
David Hradil, Institute of Inorganic Chemistry, Academy of Sciences, Prague, Czech Republic

2:15 **Texton-based Digital Painting Analysis**
Eric Postma, Tilburg University

2:45 Tea Break

3:15 **Digitally Removing Layers of Brushstrokes through Statistical Analysis of Color and Shape and with Curvature Based Inpainting**
Yubin Kuang, Lund University,
David G. Stork, Fredrik Kahl, Ricoh Innovations

3:45 **Recent Developments in Computer-aided Analysis of Lighting in Realist Fine Art**
David G. Stork, Ricoh Innovations
M. Kimo Johnson, Massachusetts Institute of Technology

4:15 **Recent Progress in the Application of Computer Graphics to the Study of Realist Old Master Paintings**
David G. Stork, Ricoh Innovations,
Yasuo Furuichi, Kanagawa, JAPAN
Gabor Nagy, SONY Computer Entertainment America

4:45 Drinks

IP4AI3 Workshop Participant List

Last Name	First Name	Affiliation	Email
Abry	Patrice	Physics Dept., CNRS, ENS-Lyon, France	*Email addresses have been*
Borghese	Barbara	The British Library	*removed from this online program.*
Cacciola	Melissa E.	Whitney Museum	
Campbell	Brenna	The Morgan Library & Museum	
Centeno	Silvia A.	Scientific Research, Metropolitan Museum of Art	
Coddington	Jim	Chief Conservation, Museum of Modern Art	
Cornelis	Bruno	Vrije Universteit Brussel	
Daubechies	Ingrid	Princeton University	
Dooms	Ann	Vrije Universteit Brussel	
Duarte	Marco F.	Princeton University	
Eisenberg	Judith	Conservator	
Figueroa	Harold	Cornell University	
Gilchrest	Alison	The Andrew W. Mellon Foundation	
Graham	Daniel	Dartmouth College	
Hale	Charlotte	The Metropolitan Museum of Art	
Hughes	Shannon	University of Colorado at Boulder	
Hughes	James M.	Dartmouth College	
Jafarpour	Sina	Princeton University	
Johnson	Don H.	Rice University	
Johnson	Rick	Cornell University	
Kiser	Spencer	Museum of Modern Art, New York	

Kuang	Yubin	Lund University, Sweden
McClintock	T.K.	Studio TKM
McClintock	Emily	Studio TKM
Morris	Suzanne	UCLA/Getty Conservation Program
Mueller	Laura J.	MyCurator LLC (UW-Madison, Art History)
Petukhova	Tatyana	Herbert F. Johnson Museum, Cornell University
Pevzner	Boris	Collectrium
Polatkan	Gungor	Princeton University
Portell	Jean D.	Independent
Postma	Eric	TiCC, Tilburg University, The Netherlands
Princ	Boris	Independent
Racco	Tiffany	University of Delaware, PhD Candidate
Ravines	Patrick	George Eastman House Museum of Photo & Film
Rockmore	Dan	Dartmouth College
Roemich	Hannelore	Conservation Center, IFA, New York University
Rosenzweig	Zeev	Program Officer, National Science Foundation
Schelkens	Peter	Vrije Universteit Brussel
Smith	Kate	Museum of Fine Arts, Boston
Stone	David	Dept of Art History, University of Delaware
Stork	David G.	Ricoh Innovations
Trujillo	Frank	The Morgan Library & Museum
Ulrich	Konstantin	Pratt Institute
Verdera	Joan	
Walthew	Jessica	Philadelphia Museum of Art

Weldon	Marianne	Objects Conservator, Bryn Mawr College
Yao	Lei	The Pennsylvania State University
Zitova	Barbara	Academy of Sciences, Prague
Zucker	Joyce	NYS Bureau of Historic Sites

Computer-assisted Connoisseurship

The interdisciplinary science of computer vision and image analysis in the study of art

David M. Stone, Department of Art History, University of Delaware
David G. Stork, Ricoh Innovations

Within the history of academic art history and scholarship, the subdiscipline of connoisseurship (the close technical and formal reading of works) fell out of favor in the 1970s. The tradition of Giovanni Morelli (1816-91),Bernard Berenson (1865-1959), and their followers for authentication, identification of hands in a work, tracing of stylistic influences among artists, and establishing aesthetic benchmarks (about "quality") was largely rejected as something only curators should concern themselves with, not academic scholars. Connoisseurship was parodied as an elitist endeavor wherein a monocled expert made subjective judgments in a refined, sometimes arcane vocabulary, judgments asserted to be beyond scholarly debate. Occasionally, the scholarly impartiality of such experts was questioned due to their financial ties to dealers and auction houses. At the same time, new critical approaches such as feminism, Marxism, post-colonial theory, and others – which questioned old hierarchies and the "authority" of the connoisseur (and even the "valorization of the object") – came into ascendency in leading university art history departments. As a result, art history split into two camps that have continued to diverge to varying degrees in methodology, terminology, and objectives, leaving "museum people" in one branch of the discipline and "academic art historians" in another. Only recently, as many scholars have moved beyond theory, have there been signs that the two branches are beginning to intertwine again.

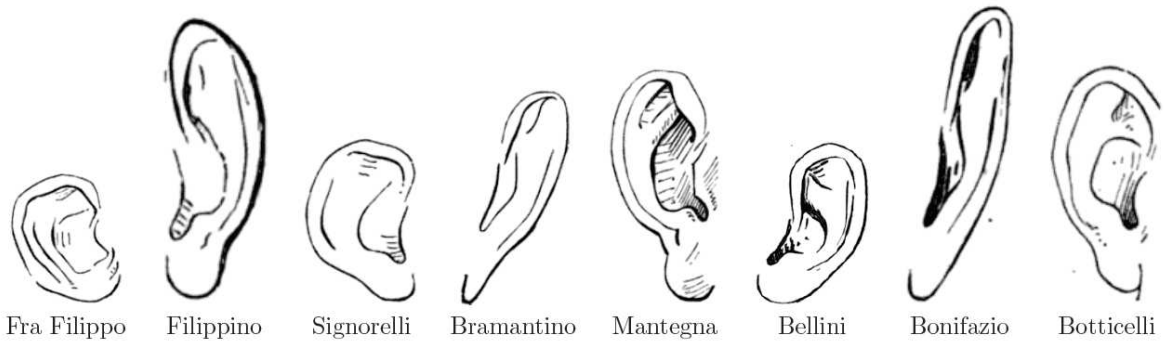


Figure 1. Giovanni Morelli's sketches of characteristic ears by several Renaissance painters. He also sketched hands and eyes and described other characteristics of such artists to help in the "scientific" identification, authentication and interpretation of their works. New supporting computer-based methods for identification allow art scholars to employ objective features such as wavelet coefficients and subtle statistical relations among visual features automatically extracted from large corpora of high-resolution images of art works.

Art history seems poised to embrace a resurgence in connoisseurship, motivated in part by a "new formalism" in literary and visual studies, and also by a new interest in the way both Early Modern and Modern art markets were developed and the role therein of connoisseurs in establishing prices, developing concepts of authorship and authenticity, and promoting certain types of collecting and documentation. We argue that future art historians will return to many of the traditional methods of connoisseurship (close study of objects in the original and where possible, in situ) and that these

methods will benefit by utilizing the rigorous methods developed in computer vision and scientific image analysis. Several of the techniques of traditional connoisseurship have counterparts in, and can be enhanced by, computer vision methods:

Close comparison of works: Computer methods can aid in revealing subtle differences between works (for connoisseurs to interpret) but more importantly quantify the differences objectively. Such computer methods support diachronic studies of a given artist as well as studies of artistic influence.

Presentation of works in non-traditional ways: Connoisseurs sometimes present art works in unusual ways, for instance inverting an art work, so as to allow the connoisseur to concentrate on style (brush strokes, shading, color, and so on) rather than on the subject matter. Computer image methods, too, often represent images in unusual ways, including wavelets or fractal coefficients or multi-spectral images, thus allowing the connoisseur to concentrate on style rather than content.

Brush stroke analysis: Art scholars study brush strokes to identify artists as well as the number of hands in a single work; new computer methods use subtle statistical tests to similar ends.

Lighting analysis: Art scholars have employed cast shadow analysis, but new computer methods reveal lighting inconsistencies within a tableau, thus providing information about the studio conditions and artists' praxis.

Computer methods introduce new analytic tools to art scholarship as well:

New visual measures: Computer image methods introduce fractals and multifractals – visual features that may be difficult to discern by eye.

Computer graphics: Computer graphics reconstructions of studios and tableaus allow scholars to explore “what if” scenarios to infer artists' working methods, including possible use of drawing aids. Computer graphics can also reveal some properties of lighting in realist paintings better than can the expert eye.

Machine learning: Connoisseurs develop insight through extensive viewing of large numbers of works. Computer methods permit the statistical learning of regularities extracted from large digital corpora of works, corpora that can be extremely large or specially selected.

Computer vision methods do not replace expert connoisseur judgments, of course, but rather enhance and extend them – much as a microscope empowers a biologist. This talk, by an art historian familiar with recent developments in computer image analysis, will be directed to both art scholars, who will use these new methods, as well as to computer scientists, who will develop them. The talk will address problems in different languages and methodologies in the different disciplines, all in order to foster interdisciplinary collaboration.

The talk presents a vision of new art historical methodology: a rich and powerful merging of traditional methods – close readings and comparisons of works, textual analysis – with new computer vision analysis methods, all employed by experts fully versed in art historical questions and contexts.

Canvas Weave Match Cliques in Vincent van Gogh's Paintings

Don H. Johnson, Rice University
C. Richard Johnson, Jr., Cornell University
Ella Hendriks, van Gogh Museum

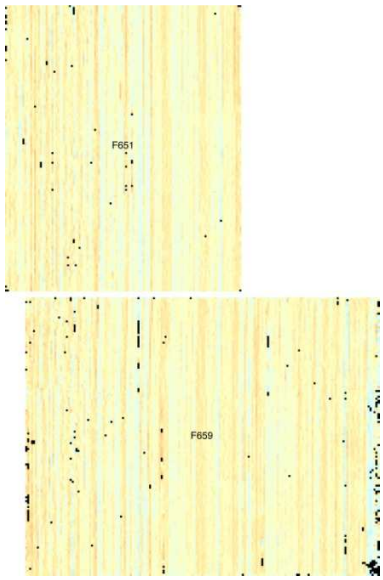


Figure: An example canvas weave match between two paintings of Vincent van Gogh. Here, color represents the thread density in this location for threads running in the vertical direction.

Because the ground used to prepare the canvas is x-ray opaque, the weave of the canvas used in master paintings can be analyzed from x-ray images. Until recently, the canvas weave has been analyzed by using a light table, a magnifying glass and a ruler to count the number of vertical and horizontal threads within a short distance (less than an inch) at several places (typically less than ten). We have developed a nearly automatic method of analyzing the canvas weave that results in thread counts everywhere in an x-ray. The physics of the x-ray imaging process shows that the contributions of the paints, ground, wood frame, stretcher keys and tacks sum to produce the x-ray image. The canvas weave appears as small-amplitude, approximatelytwo-dimensional sinusoidal variations in computer scanned x-rays. Frequency domain analysis of small overlapping swatches provides the core technique used in creating weave maps. The weave is evident as strong peaks located near the vertical and horizontal frequency axes. Weave maps are determined by the distance of these peaks from the origin and angle maps, the angular displacement of the spectral peaks from the coordinate axes, show the threads' orientations.

These detailed weave maps indeed indicate that the thread count varies in a characteristic way, providing a kind of fingerprint for the weave pattern. This fingerprint is not unique to the painting, but to the larger canvas from which the painting's support was extracted. The angle maps reveal the presence of cusping and manufacturing anomalies. By using correlation techniques, we can determine which paintings align in warp or weft, with weft matches being the most problematic. The figure shows a typical warp weave match for two of van Gogh's paintings (F651 and F659 in de la Faille's catalog).

In combination with angle maps, we can localize a painting's position on a roll. In some cases, the weave matches we have found are changing painting dating. To date, we have over twenty weave-match

groups, the largest of which consists of thirty-three paintings. The latter weave-match clique is far too large to have come from the same roll. Investigations of commercial priming operations reveals that pre-primed canvas rolls are cut from much longer lengths of canvas we term bolts. Warp weave matches, far and away the most prevalent match type we find, alone can only segregate paintings to a bolt; weft weave matches definitively place paintings on the same roll. Further evidence for grouping paintings made from the same canvas roll comes from the letters van Gogh wrote to his brother and fellow artists. They document the purchase of canvas rolls and generally describe the paintings made from each roll. By analyzing as many paintings from van Gogh's oeuvre as possible, we hope to reconstruct painting locations on rolls and learn more about his painting practices.

Digital Analysis of Paintings by Vincent van Gogh and Norval Morrisseau

Lei Yao, Jia Li, and James Wang, Penn State University

We study paintings from two artists, i.e. Vincent van Gogh and Norval Morrisseau, and develop different approaches to analyze their painting styles. We focus on characterizing the rhythmic brushstroke styles of Vincent van Gogh. A novel extraction method is developed by exploiting an integration of edge detection and clustering-based segmentation. Evidence substantiates that van Gogh's brushstrokes are strongly rhythmic. That is, regularly shaped brushstrokes are tightly arranged, creating a repetitive and patterned impression. We also found that the traits that distinguish van Gogh's paintings in different time periods of his development are all different from those distinguishing van Gogh from his peers.

On the painting styles of Norval Morrisseau, we propose measures of curve steadiness and neighborhood coherence to capture the curve elegance in his works. Through computerized analysis of his authentic works and the imitations, it is revealed that the curves in his authentic paintings exhibit his commanding painting skills. The smooth and steady flow of the curves shows less hesitancy of the artist than the authors of counterfeit works. The tangent angles tend to be more consistent along curves in the authentic paintings than in the imitations.

Spatial Approaches to Digital Stylometrics

James M. Hughes, Daniel J. Graham, Daniel N. Rockmore, Dartmouth College,
James Coddington, Museum of Modern Art, New York

Quantitative descriptions of artistic style have recently been used to help solve questions of attribution and to describe the evolution of style in the works of a particular artist. Increasingly, non-destructive digital techniques for the analysis of art are becoming important for the study and conservation of art, and, naturally, the analysis of style plays a significant role in this process. However, as in many fields, the concept of artistic style is difficult to define (and thus to quantify). We propose to quantify style using various statistical descriptions of spatial structure. We introduce novel techniques for visualizing artistic style, displaying important relationships between styles in the form of networks. Finally, we discuss extensions to previous models of spatial structure that incorporate more complex statistical models, and future work based on these models.

Underpainting Recovery with Xray Synchrotron Imaging and Image Processing

Shannon Hughes, University of Colorado at Boulder
Ingrid Daubechies, Andrei Brasoveanu, Marco Duarte, Princeton University
Joris Dik, TU Delft

Figure: Digital reconstruction of a woman's portrait lying underneath Vincent van Gogh's "Pasture in Bloom"

The final years of Vincent van Gogh's stay in the Netherlands 1882-83 were important developmental ones for his subsequent artistic career. Casper de Jong writes that "in both years at The Hague [van Gogh's] drawing technique advanced with giant strides," emphasizing the improvement in the painter's style. Whether he was dissatisfied with some of his work in this period, or because his financial constraints did not permit buying enough canvas, van Gogh is known to have reused a considerable number of canvases from this period, repainting over earlier works. For example, an X-ray analysis performed on about 130 paintings from this period held by the Van Gogh Museum in Amsterdam, revealed that 20 of these contained previous works underneath.

The presence of such underpaintings is sometimes visible in three-dimensional ridge patterns on the surface of the painting. However, more commonly, underpaintings are glimpsed via non-invasive imaging methods such as infrared or Xray imaging of the work. However, the data these can provide about an underpainting is limited and virtual reconstructions of such paintings can be of great use to art scholars studying the artist's work during such a period.

In this talk, we describe efforts to create virtual reconstructions of underpaintings. The particular underpainting examined in this case study is a woman's portrait underneath Vincent van Gogh's *Pasture in Bloom* (1887, De La Faille catalog number: 583, Kröller-Müller Museum). First, a synchrotron radiation based X-ray fluorescence mapping technique is applied to the painting, without harming it, to create a set of images, each showing the

spatial distribution of a specific chemical element (As, Ba, Bl, Cd, Co, Cr, Cu, Fe, Hg, Mn, Pb, Sb, Sr, and Zn) within the painting.

Image processing on data of this type is then used to produce a digital reconstruction of the underpainting's appearance from the chemical element data. In particular, alignment errors in the data set that are the result of a timing problem in the acquisition process are fixed through an automated procedure we developed. We further use image processing methods to identify and inpaint areas where the underpainting signal was likely obscured by surface features. Finally, we estimate a coloring for the portrait using information from the chemical element data as well as color distributions from similar portraits of women. The figure shows a final virtual reconstruction of the obscured portrait.

A Registration and Normalization Open Source Program for Images and Photographs

Patrick Ravine, George Eastman House International Museum of Photography & Film
Maria Helguera, Karl Baum, Rochester Institute of Technology

We will present a short overview of a new open source registration and normalization program that we have developed. The purpose of the registration program is to 'align & resize' images/photographs from different sources and different imaging modalities to allow for proper comparison. In our case, we have been using the program to compare images/photographs of 19th century whole plate (6.5 x 8.5 inches) daguerreotypes taken in the 1970s, 1980s, 2005 and 2009/10; to compare axial specular images with standard illumination, and UVA fluorescence with standard illumination. The comparison of images from 1970s versus 2005 reveal where chemical and physical damage have appeared as a function of time, storage and mishandling. Meanwhile, comparison of UVA fluorescence versus standard illumination images show that what appears as a whitish-bluish tarnish under standard illumination appears to occupy a larger area under UVA.

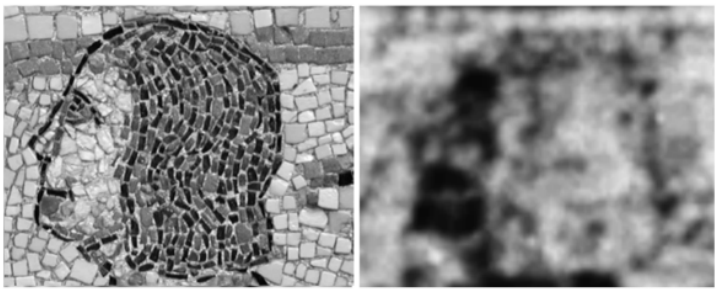
This fundamental program is of potential use to curators, art historians and conservators studying changes art objects have undergone since they were captured and documented with film and now with digital imaging systems. This is an area that can also be developed and refined further.

Between Pigments and Pixels

Barbara Zitova, Institute of Information Theory and Automation, Academy of Sciences, Prague
Janka Hradilova (art expert), Academy of Fine Arts, Prague, Czech Republic
David Hradil, Institute of Inorganic Chemistry, Academy of Sciences, Prague, Czech Republic

This talk will review a fruitful cooperation of the Czech Academy of Fine Arts (Conservation laboratory) and of two Institutes belonging to the Czech Academy of Sciences - Institute of Information Theory and Automation and Institute of Inorganic Chemistry. This joint effort tries to exploit rich expertise in image processing and in material science in order to provide as good as possible a priori knowledge of the old artworks to the art conservators. The application of image processing science entered various projects including painting underdrawing study, restoration of old glass mosaic, or material analysis of microscopic sections. Several examples will be covered such as:

CONSERVATION OF THE LAST JUDGEMENT MOSAIC



An application of digital image processing for the analysis of the medieval mosaic conservation. The reconstructed art piece was ”The Last Judgment” mosaic, situated on the wall of the St. Vitus cathedral in Prague, Czech Republic. It was completed in 1371, under the reign of King Charles IV. The historical photograph of the mosaic from the 19th century was compared with the photograph of the current state. The images were preprocessed to increase their quality, geometrical deformations were removed and finally, differences between the current and historical photographs were identified.

WALL PAINTING ANALYSIS SUPPORT

An application of digital image processing algorithms for the process of fresco restoration. Modern methods for image preprocessing and evaluation such as image registration, image fusion, and image segmentation are applied on images of the fresco, obtained in different modalities (visual and ultraviolet spectra) and at different times. Moreover, local chemical analyzes are taken into account during the image analysis. Achieved results can give to art restorers better insight into the evolution of the fresco aging and in this way a proper conservation method can be chosen.

ELECTRONIC DATABASE FOR MATERIAL RESEARCH OF PAINTINGS

A comprehensive information system for processing and archiving material analyses data produced during art restoration process. The database system is extended with image analyzing modules - image registration, segmentation, and object description and classification - designed for archiving and working with material analyses reports. The aim of the material analyses of paintings is to identify inorganic and organic compounds using micro-analytical methods, and to describe painting layers and their morphology. Archiving all these data, the database can act as a knowledge base and an expert system for future advanced analyses. Image-type data of the archived reports are pre-processed, analyzed, and described for further evaluation. Moreover, next to the classical text-query database search the database supports report retrieval based on the similarity of the sample image to the archived image data, which can notably facilitate selection of relevant records to the current restoration case.

Texton-based Digital Painting Analysis

Eric Postma, TiCC, Tilburg University

We propose a new method to support art-historians in their visual assessment of paintings. The method is based on textons, the building blocks of painted texture. Texton-based methods have been shown to be highly successful on texture classification and texture analysis tasks. Building on the work of Varma and Zisserman (2009) and van der Maaten (2009), we adapted the texton-based approach for the analysis of paintings. A multi-scale codebook of prototypical painted textures is automatically created from a reference collection of paintings using a fast similarity-based clustering method. Textural similarities within the collection are quickly determined using histograms of the codebook representation. The method is incorporated in an interactive tool that supports the visual assessment of paintings by: (i) visualizing similar regions within and across paintings and (ii) enabling to (de)emphasize features such as color and orientation.

Digitally Removing Layers of Brushstrokes through Statistical Analysis of Color and Shape and with Curvature based Inpainting

Yubin Kuang, Lund University,
David G. Stork, Fredrik Kahl, Ricoh Innovations

Underpaintings and pentimenti (revealed through x-ray imaging and infrared reflectography) are important evidence revealing the intermediate states of a work and thus the working methods of many artists. Although such images do not reveal the color of the underdrawings directly, chemical channel information can be used to recover estimates of the hidden colors. Based on digital image processing and statistical analysis, Shahram, Stork and Donoho introduced the De-pict algorithm, which recovers layers of brush strokes of van Gogh's Self portrait with grey felt hat. What that preliminary work served as a proof of concept that computer image analytic methods could recover some occluded images, the work needed further refinement before it could be a tool for art scholars.

Our current work rectifies this omission. We extended that earlier work by refining the algorithm using "ground truth" data: passages of layers of brush strokes in which the intermediate layers were recorded photographically (Fig. 1), where there are five layers of bush strokes (orange, red, yellow, green and blue from top to bottom). At each successive top layer (currently identified by the user), we use K-Means combined with Graph Cuts to obtain chromatically and spatially coherent segmentation of brush strokes. We then reconstruct strokes at the deeper layer with the inpainting algorithm based on curvatures of chromatic level lines.

The initial results suggest the potential of the method for this task (Fig. 1). We are currently working on automatic identification of top layer of brush strokes based on shape variation statistics. To improve the inpainting step, we are investigating the learning of curvature penalty, and the combination of exemplar-based method with the level line curvature based framework.

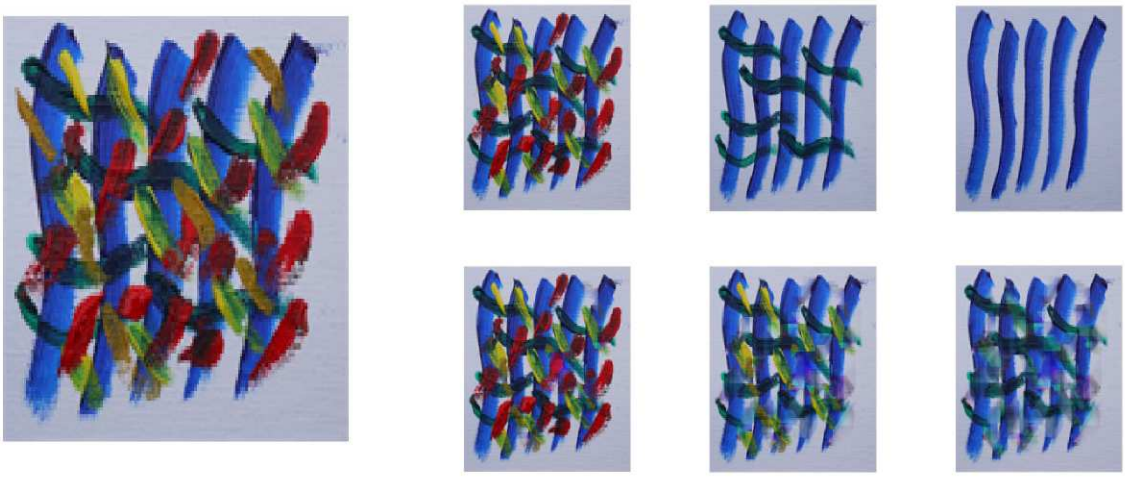


Figure 1. The final painting is on the left. On the right, the original creation process was top row, read right-to-left; our reconstruction of the painting with top brushstrokes removed is the bottom row, read left-to-right.

Our methods, slightly modified, may be applied to the drip paintings of Jackson Pollock as well, where the color segmentation step is more accurate because Pollock poured unmixed car paint. The method may also aid in the representation of strokes for authentication.

Recent Developments in Computer-aided Analysis of Lighting in Realist Fine Art

David G. Stork, Ricoh Innovations
M. Kimo Johnson, Massachusetts Institute of Technology

Computer vision methods such as lighting estimation and shape-from-shading have been applied to a number of problems in the history and interpretation of art (Fig. 1). The occluding contour algorithm, used in forensic photography analysis, estimates the direction of illumination from the pattern of luminance (lightness) along the outer boundary or occluding contour of a diffusely reflecting object. Sophisticated extensions to this algorithm characterize the lighting in arbitrarily complex lighting environments. Computational methods for inverting the forward appearance model of planar surfaces reveal the location of the source of illumination. Bayesian statistical methods integrate lighting estimates from disparate sources in a statistically optimal way.

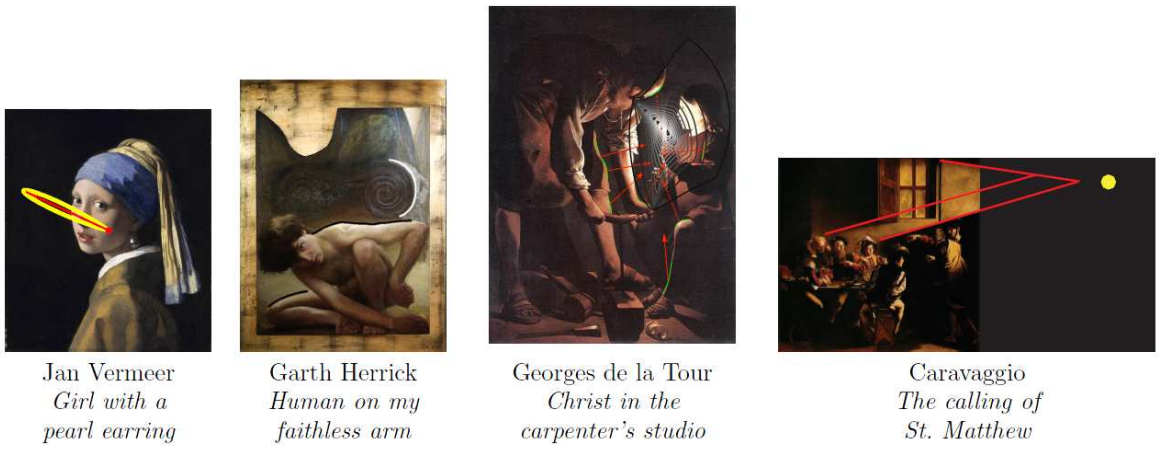


Figure 1. Vermeer: The lighting direction estimated by the occluding contour algorithm, shape-from-shading, and four other methods agree to within 4 degrees in Girl with a pearl earring. Herrick: The complex diffuse lighting field estimated from the background scroll differs from that on the figure, revealing that these portions in Human were indeed executed under different lighting conditions. de la Tour: Bayesian statistical methods integrate diverse types of lighting evidence throughout the tableau to compute a contour graph showing that the most likely location of the illumination is at the candle. Caravaggio: Computational inversion of the forward appearance model of the rear wall in Calling reveals the light source was likely a few meters outside the frame of the painting.

These computer methods allow art scholars to study rigorously the consistency in lighting throughout a tableau, to identify inconsistencies that elude even expert visual detection, and to better understand artists' style and studio praxis, such as whether an artist may have used optical aids. This talk will focus on the assumptions that underly the use of these methods, explain how they are used, and describe the types of art historical and interpretive questions to which they can be addressed. As with all computer methods in the study of art, it is essential that these methods be guided by deep knowledge of the target art work, its artist's oeuvre and working methods, as well as its cultural context.

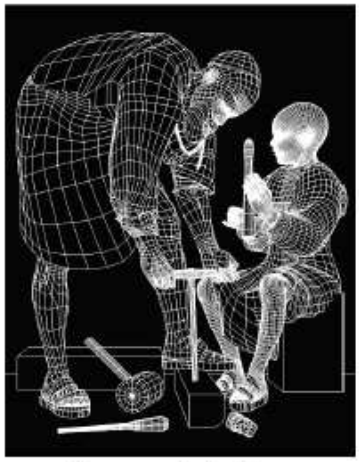
Recent Progress in the Application of Computer Graphics to the Study of Realist Old Master Paintings

David G. Stork, Ricoh Innovations,
Yasuo Furuichi, Kanagawa, JAPAN
Gabor Nagy, SONY Computer Entertainment America

Computer graphics models of artists' studios allow scholars to address a number of vexing problems in the history and interpretation of art, particularly those related to artists' studio praxis (Fig. 1). A model of Jan van Eyck's *Portrait of Arnolfini and his wife* exposed perspective inaccuracies difficult to discern by the unaided eye.

Jan van Eyck
Portrait of Arnolfini and his wife

Jan Vermeer
Girl with a pearl earring



Georges de la Tour
Christ in the carpenter's studio

Diego Velàzquez
Las meninas

Caravaggio
The calling of St. Matthew

Parmigianino
Self portrait in a convex mirror

The model also confirmed that the focal length of the depicted convex mirror was much shorter than putative projection mirror for this work, both results leading to a rejection of the claim that this work was executed by tracing optical projections. The lighting direction estimated in a model of Jan Vermeer's *Girl with a Pearl Earring* agreed closely with directions estimated by five other sources within the painting, revealing objectively this artist's mastery in rendering the effects of light and supporting the

claim this work was executed with a live model, not from the artist's imagination. A model of Georges de la Tour's *Christ in the carpenter's studio* confirmed that the light in the tableau was at the candle, rather than “in place of the other figure” and this, in turn, led to a rejection of the claim this painting was executed using optical projections. A model of Diego Velazquez's *Las meninas* revealed that the reflected image of the king and queen in the plane mirror on the rear wall is likely a reaction of the painted image of the royal couple on the hidden side of the large depicted canvas rather than of figures in the position of the viewer, a results that challenges one reading of the work. A model of Caravaggio's *The calling of St. Matthew* revealed constraints upon the lighting and geometry of the studio and lighting and exposed the constraints needed for a local illumination configuration and a distant solar illumination. A model of Parmigianino's *Self portrait in a convex mirror* revealed that the warped image is consistent with the artist faithfully recording the image of a rectilinear room distorted by the mirror, rather than inventing a fictive space. The model also reveals that the work may be hung too high in its gallery home. A simple, plane model of Hans Memling's *Virgin and Child* and Maarten van Nieuwenhove diptych revealed inconsistencies between the warped image in the convex mirror and the likely tableau itself, thereby supporting the claim that this mirror was added as an afterthought.

Realist paintings are constructed artifacts and most painters (including Renaissance masters) who carefully observe nature nevertheless render their subjects with a personal style that deviates from a “photographic” rendering. Nevertheless, computer models, which implement consistent physics and optics, are useful in analyzing such works. For instance, computer graphics models reveal where and how an artist deviated from a “faithful” reproduction of the tableau before him. Such results may then be the starting point for art historical investigation and interpretation.

This talk for art scholars – profusely illustrated with art works and movies of computer graphics models of artists' studios – will show the steps by which computer experts together with art scholars build such computer graphics models, the types of assumptions that are brought to bear, and the strengths and limitations of the overall methodology. It is essential that such research be informed by expert art historical knowledge of the artist in question, his oeuvre, context, known working methods, and to the extent possible, that the scholarly question admit an objective, verifiable answer, rather than a personal interpretation.

Slide handouts have been omitted from the online program

because of sensitive images contained therein.