



Future Directions

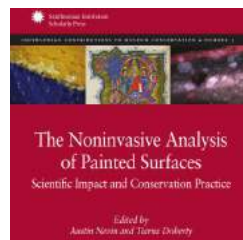
17 November 2016

Austin Nevin



What about the Future trends?

- Recent trend towards multi-analytical and multi-instrumental approaches
- Mapping and Imaging
- Non-invasive techniques are increasingly being used intelligently to answer key questions in preventive and practical conservation



5I's: General trends

- Instrumental Advances
- Integrated Approaches
- Intelligent Applications
- Interpretation and Assessment
- International Publications & Dissemination

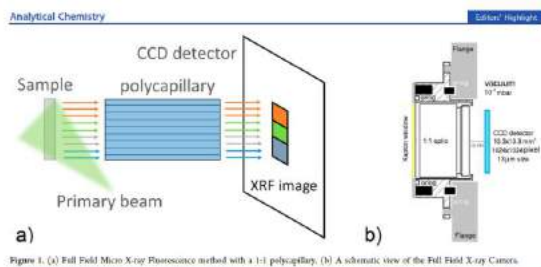
Instrumental Advances

- Lasers are becoming cheaper and smaller
- Sensors are developing for some applications (X-ray detection, FTIR)
- Motorisation is being combined to allow scanning and 3-d imaging/sensing
- There will always be new instrumentation
 - NMR Mouse
 - ATR devices
 - Atmospheric MALDI

Instrumental Advances: Example X-ray fluorescence scanning

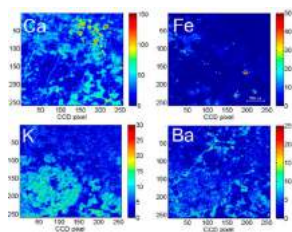
- Combine XRF with a scanning instrument
- For the moment this has been limited to paintings - but this could be extended to 3-d objects
- Use rapid Si-drift detectors to acquire spectra and scan an area

X-ray fluorescence imaging



DOI: 10.1021/acs.analchem

XRF maps of Lapis Lazuli

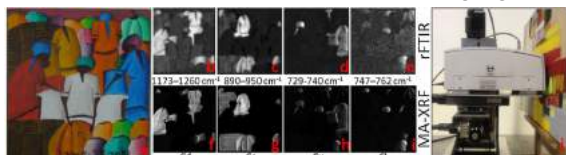


The pattern of Ca-rich and K-rich phases, detected with high lateral resolution, together with the presence of traces of Ba and inclusions of Fe (Pyrite) constitute a fingerprint for the Siberia source. DOI: 10.1021/acs.analchem

Instrumental Advances: XRF mapping



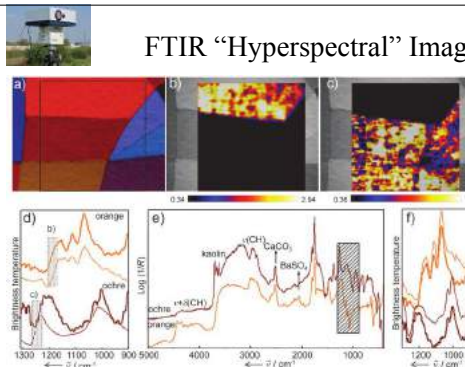
Instrumental Advances: FTIR Imaging



DOI: 10.1186/2096-7445-2-13

Antillean folk art painting (8×8 cm²), of assumed 20 th Century origin. A) Visual image; MA-FTIR chemical distribution images: B) cadmium lithopone (1173–1260 cm⁻¹), C) chrome yellow (890–950 cm⁻¹), D) phthalocyanine blue (729–740 cm⁻¹) and E) phthalocyanine green (747–762 cm⁻¹); MA-XRF elemental distribution maps of F) cadmium, G) chromium, H) copper and I) chlorine; lighter tones indicate higher levels of net pseudo absorbance or X-ray fluorescence intensity; J) Photograph of MA-FTIR device in front of a large canvas, scanned area: 76×76 mm², step size: 1 mm in both directions, dwell time: 8 s/pixel.

FTIR “Hyperspectral” Imaging



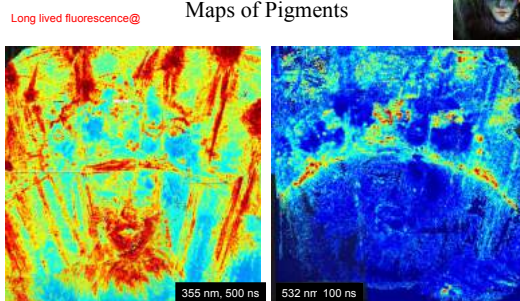
Angewandte Chemie International Edition 52(20) · May 2013, DOI:10.1002/anie.201209929

Instrumental Advances: Fluorescence Lifetime Imaging

Umberto Boccioni: Modern Idol (1911)
25 images @ 355 and 532 nm Estorick Museum London



Lifetime Imaging Maps of Pigments



Integrated Approaches

- Combine instrumentation to gain more complete assessment
 - Laser Scanning + Photogrammetry
 - OCT + Spectral Imaging
- Use more than one technique
- Many examples including XRF-Raman have been produced
- Scanning: IR+VIS
- The same setup for XRF+XRD

Interpretation and Assessment

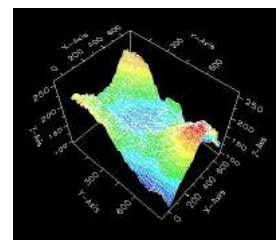
- Free Access to databases
- Free Software
- Better networks and user working groups (IRUG)
- User interfaces make operating instruments easier
- Increase in the number of publications suggesting interpretation for spectra in conservation
- Use statistical methods to assess data and images

Intelligent Applications

- Research driven investigations
- In depth studies to examine materials and their ageing
- Assess treatments in real time
- Understand and prevent deterioration

Laser-based analytical techniques

Assessing the effect of RH on works of art: paintings on wood



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Context: RH on works of paintings on wood

- Many paintings are on wood – crucifixes, fayuum, sarcophagi, panels, icons, etc.
- Wood is a hygroscopic material:
 1. Wood support and paint Absorbs humidity and changes shape
 2. Changes in RH and T can cause significant damage or dimensional change
 3. Few methods for monitoring of effect on paintings

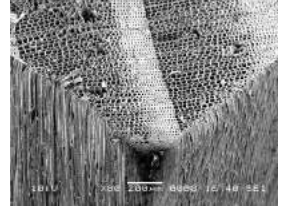


© Sandberg, et al. Applied Optics, 2003
 © Andrade, et al. Applied Spectroscopy, 2007

Assess the effect of RH on works of art: paintings on wood

• Questions

1. Is it possible to measure variations in the moisture content of wood using non-contact laser-based spectroscopic techniques?
2. Can real-time movement of paintings as a function of changes in ambient conditions be measured?
3. What degree of change can be measured **how fast is dimensional change?**

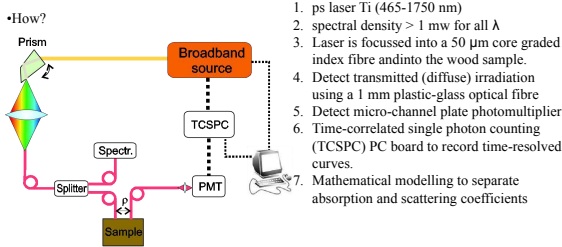


Analytical Techniques:

1. Time-resolved diffuse reflectance spectroscopy
2. Digital Holographic Speckle Pattern Interferometry (DHSPI)

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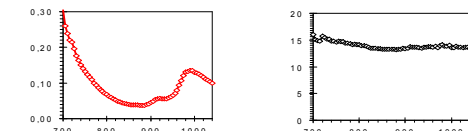
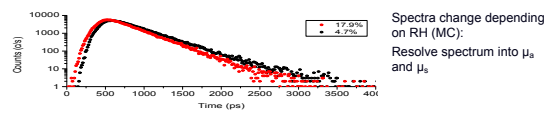
Wood and RH: Basics of time-resolved absorption spectroscopy



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© D'Andrea, et al. Applied Spectroscopy, 2007

Wood and RH: Basics of time-resolved absorption spectroscopy



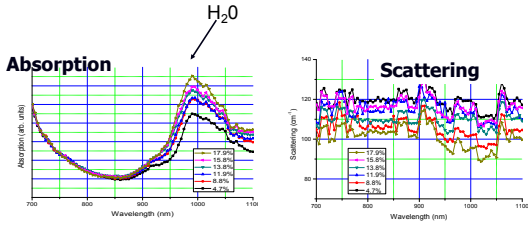
Absorption spectrum (μ_a) \rightarrow concentration of constituents (lignin, cellulose, and H_2O) by Beer's law

Scattering spectrum (μ_s) \rightarrow structure of wood

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Wood and RH: Time-resolved spectroscopy

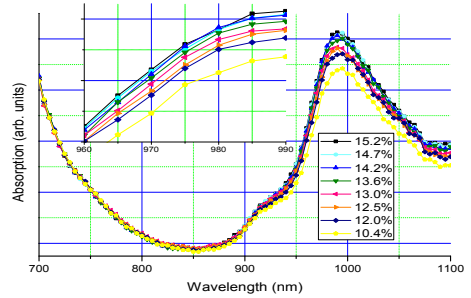
- Coniferous European Silver Fir (*Abies alba*) (cut into samples of: 5 cm x 5 cm x 5 cm)
- Static differences in moisture content**
- Blocks of wood were conditioned in sealed plexiglass boxes with saturated solutions
- RH varied between 12% to 94% at 25 C
- moisture contents of wood were achieved ranging from 4.7-17.8%.



C. D'Andrea, et al. Applied Optics 2008

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Wood and RH: Consider Dynamic Time-resolved spectroscopy of wood with Δ RH



1. even very small differences (1%) in MC → differences in absorption spectra
2. particularly advantageous for the monitoring of samples during humidity changes

C. D'Andrea, et al. Applied Optics 2008

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Wood and RH: Basics behind the assessment of movement using Holographic Interferometry

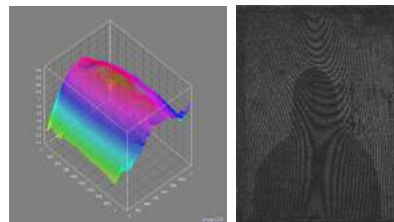


The fringes visualise the effect on the surface of detachment

F. Toman, Analytical and Bioanalytical Chemistry, 2007

F. Toman, et al. Sensors, 2008; P. Knežič, et al. Applied Optics, 1997

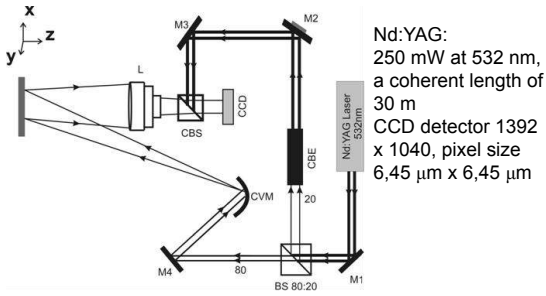
Detection of movement following change in conditions (change in T)



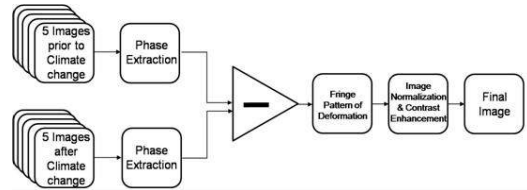
Multi-Ensemble Step 10:10.2003 WP1:101:DA:MI

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Holography Working set up



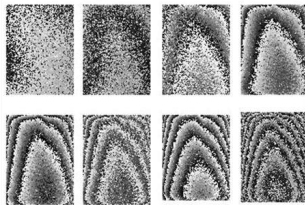
Digital holographic speckle pattern interferometry



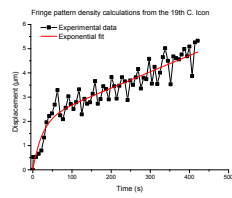
Wood and RH: Digital Holographic Speckle Pattern Interferometry



Change environmental conditions (RH) and record interference patterns in real time (every 6 seconds following change)

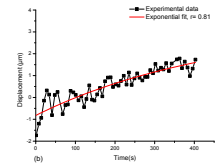


Wood and RH: Digital Holographic Speckle Pattern Interferometry



Movement continues after 30 minutes with a total displacement of ~20 micrometers

Displacement from the centre of the panel to the right edge/time for an isothermal humidity change from RH 23-58%



18-27 minutes after change

Analysis of wooden materials

Research Questions

- Is it possible to measure variations in the moisture content of wood using non-contact laser-based spectroscopic techniques?
 - Time resolved absorption spectroscopy may provide means but relies on light coloured materials (darker materials will absorb more radiation)
 - Alternative methods may require use of electrode/sensors
- Can real-time movement of paintings as a function of changes in ambient conditions be measured?
 - DHSP1 provides a unique non-contact method
- What degree of change can be measured **how fast is dimensional change?**
 - Micrometer-level changes (<2 micrometers depending on S/N)
 - Very rapid dimensional changes occur with change in RH
 - Movement begins within seconds (detected within 6 seconds with DHSP1)
 - Movement continues for many minutes

Berkebile, et al. Applied Physics A, 2009

Articles in Studies in Conservation@ IIC

Original research paper: Optical and spectroscopic tools for evaluating Er:YAG laser removal of shellac varnish

Jana Strižová¹, Barbara Salvadori², Raffaella Fontana², Antonio Sansonetti², Marco Barucci², Enrico Pampaloni², Eleonora Marconi², Luca Pezzati², Maria Paula Colombini²

¹National Institute of Optical Science, Brno, Czechia; ²Institute for the Conservation and Restoration of Cultural Heritage (ICR), Santa Margherita (MI) and Milan, Italy; ³University of Florence, Florence, Italy

Microport or both to remove residual and artificially aged shellac varnish by laser and traditional chemical cleaning. Both the suitability of major portable optical tools were used for the evaluation of cleaning processes. In particular laser interferometry to assess the changes in the surface morphology and time-domain confocal optical coherence tomography (CTO) to evaluate varnish thickness. The cleaning effectiveness was integrated with microscopic characterisation provided by confocal Raman spectroscopy operating in reflectance mode and subsequent measurements. The complete analytical approach was fully implemented on treated and untreated samples in the presence of impregnations, which allowed continuous and safe partial removal of varnish without alteration in the substrate morphology.

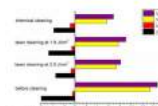


Figure 4. Electrostatic evaluation of the cleaning efficiency for the artwork type systems.

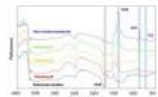


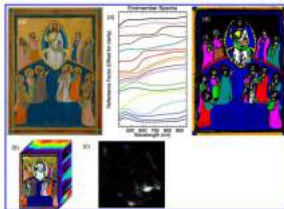
Figure 5. Infrared reflectance spectra before and after laser treatment of wood in treated with shellac, cleaning B, C, D, and non-treated substrate.

Articles in Studies in Conservation@ IIC

Original research or treatment paper

Use of imaging spectroscopy, fiber optic reflectance spectroscopy, and X-ray fluorescence to map and identify pigments in illuminated manuscripts

John K. Delaney¹, Paola Ricciardi², Lisha Dering Gámaral³, Michelle Facini⁴, Matthew Thoury⁵, Michael Padover⁶, E. René de la Riva⁷



Articles in Studies in Conservation@ IIC

Original research or treatment paper

Distribution of moisture in reconstructed oil paintings on canvas during absorption and drying: A neutron radiography and NMR study

Ruel Hendrickx¹, Ester S.B. Ferreira^{1,2}, Jeep J. Boon¹, Guyline Desmarais¹, Dominique Derome¹, Lore Angelova¹, David Mennet¹, Anders Kvaestad¹, Henk (H.P.) Huilink¹, Kees (C.J.) Kuipers¹, Benjamin Voegt¹ and Emma Richardson¹

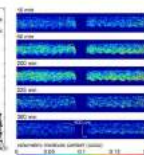
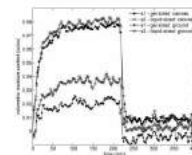


Figure 2. Absorption of moisture absorption and desorption in various types of oil paintings. Left, vertical distribution, combined in series and colour of both samples versus time. Right, snap-shots of the moisture distribution of five different points in time. Each scale bar represents 100 µm (see image in attached in the vertical direction).

International Dissemination and Publications



- IIC Studies in Conservation*
- Special Issues in Studies in Conservation
 - LACONA
 - LACQUER
- National Gallery Technical Bulletin
- British Museum Journals
- Getty Conservation Institute Publications
- Dedicated scientific publications from other journals and publishers
 - Pigment Compendium



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International Dissemination and Access to knowledge

- Conferences
 - IIC Biennial Congresses
 - See IIC Website for events and other congresses
 - Consdistlist
 - Dedicated scientific conferences but most are not with or for conservators
 - XSA
 - IRUG (very small)
 - TECHNART 2017

