Characterization of hidden defects of an original XVI Century painting on wood by Electronic Speckle Pattern Interferometry

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ESPI
Electronic Speckle Pattern Interferometry

NON CONTACT - NON DESTRUCTIVE
HIGH SENSITIVITY

NDT OPTICAL INTERFEROMETRY
FOR INDUSTRIAL DIAGNOSTICS

VIBRATION MODES
QUALITY TESTING
DEFORMATIONS

INCREASINGLY UTILIZED
AS DIAGNOSTIC TOOL
IN THE CULTURAL HERITAGE FIELD
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ESPI - IDEAL TOOL FOR CULTURAL HERITAGE DIAGNOSTICS

HIGH SENSITIVITY (AT SUB MICROMETRIC SCALE)
NON CONTACT (THE OBJECT UNDER TEST IS SIMPLY ILLUMINATED BY A LOW INTENSITY LASER LIGHT)
NON DESTRUCTIVE (NO HANDLING - NO COLLECTION OF SAMPLES FROM THE ARTWORK)
REAL-TIME MEASUREMENTS

INTERFERENCE FRINGES OVERLAY THE IMAGE OF THE OBJECT
EASY INTERPRETATION OF FRINGES
LOCALIZATION OF DEFECTS
QUANTITATIVE RESULTS

- MICRO-CRACKS
- DETACHMENTS
- STRUCTURE DEFORMATIONS
- STRESS CONCENTRATIONS
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**WOODEN ARTWORKS**

**SUPPORT**

**PICTORIAL LAYERS**

**WHOLE STRUCTURE DEFORMATION**

**TYPICAL DAMAGES INDUCED BY MICRO-CLIMATE VARIATIONS**

**INITIAL STAGE DETACHMENT**

**FINAL RESULT: CRACK**

**LOCAL DAMAGES**

Interferometric analysis is applicable on almost any typology of artwork

- Frescoes
- Wooden Sculptures
- Mosaic
- Pottery
ESPI  
Electronic Speckle Pattern Interferometry  
Utilizing Digital Technologies

- COMPACT SELF-CONTAINED OPTICAL SET-UP  
- FAST DATA PROCESSING BY DEDICATED SOFTWARE  
- REAL TIME MEASUREMENT  
- LONG TIME MONITORING  
- OBJECT SIZE FROM FEW MILLIMETERS UP TO METERS  
- NO NEED OF OBSCURED LABORATORY

SYSTEM MAIN FEATURES
- 500 mW – 532nm Laser  
- CCD SENSOR  
- 30 ftg/sec.  
  (Acquisition + Numerical Processing + Visualization.)  
- Size: 450x450x160 mm

MOVABLE FOR IN-SITU UTILIZATION

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Examples of fringe interpretation

General curvature of fringes → Curvature of the whole structure

Real-time holographic interferometry for painting conservation and restoration - S. Aurisicchio, A. Finizio and G. Pierattini
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ESPI SURVEY ON A WOODEN PAINTING

TRADITIONAL ART CONSERVATORS SURVEY METHODS ON PICTORIAL LAYERS

- RAKING-LIGHT IMAGING
- VISUAL INSPECTION BY “EXPERIENCED” UNAIDED EYE OR WITH OPTICAL MICROSCOPE
- ACOUSTIC METHOD BY “EXPERIENCED” EAR (GENTLE TAPPING ON THE SURFACE)

«MADONNA CON BAMINO E SAN GIOVANNINO»  
XVIth Century - Author Unknown. 
Painting on wood - Size: 72x80 cm 
Collection SUOR ORSOLA BENINCASA University Naples

QUALITATIVE RISK MAP

- uprisings of the paint film
- gaps of the pictorial film
- uprisings characterized as vertical cracks
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TRADITIONAL SURVEY METHODS FOR WOODEN SUPPORTS DEFORMATION

- DISPLACEMENT SENSORS CONSECUTIVELY APPLIED ON DIFFERENT POINTS
- MEASUREMENT TAKEN AT DISTINCT TIMES
- TIME-CONSUMING PROCEDURE

M. Ciatti, C. Castelli, A. Santacesarea. “Dipinti su tavola, la tecnica e la conservazione dei supporti” -- EDIFIR - 1999
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LONG TERM REAL-TIME DISTORTIONS MONITORING OF THE WHOLE STRUCTURE

REAL TIME MOVIE OF FRINGES PROGRESSION

FRAMES EXTRACTED FROM THE REAL TIME MOVIE

ROOM TEMPERATURE INCREMENT: +2.2 °C
TOTAL MEASUREMENT TIME: 50 min
TOTAL SURFACE: 5740 cm²
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The cross-bars applied on the back are ineffective in reinforcing the entire painting.

**RESULTS**

Fringes shapes suggest an inhomogeneous structure.

...........actually it is two reinforcing bars are applied on the back.

Profiles of back cross-bars.

Whole structure distortions.
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EXPERIMENTAL PROCEDURE

THERMAL LOAD INDUCES MICROMETRIC DISPLACEMENTS REVEALED BY ESPI

ESPI EVIDENCE OF WHOLE STRUCTURE DEFORMATION AND LOCAL CRACKS

FRINGES DELINEATION ON WHITE LIGHT PICTURE

CRACKS DETECTED BY ESPI

THERMAL LOAD INDUCES MICROMETRIC DISPLACEMENTS REVEALED BY ESPI

100 W BULB + 2,8°C

I. R. THERMOMETER

ESPI SYSTEM

EXPERIMENTAL PROCEDURE

VISIBILITY
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HIDDEN DETACHMENTS OF PICTORIAL LAYERS

WHITE LIGHT PICTURE

INTERFEROGRAM

OVERLAY OF FRINGES AND WHITE LIGHT PICTURE

FRINGES DELINEATION ON WHITE LIGHT PICTURE

ESPI EVIDENCE OF NON VISUALLY DISCERNIBLE CIRCULAR DETACHMENTS
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PROBLEMATIC AREA ON THE PAINTING DETECTED BY TRADITIONAL CONSERVATION VISUAL ANALYSIS

MAP OF DAMAGES REVEALED BY RAKING-LIGHT METHOD
(VISIBLE FAULTS IN YELLOW)

ESPI EVIDENCE OF NON VISUALLY DISCERNIBLE CIRCULAR DETACHMENTS

NOT DETECTED BY TRADITIONAL CONSERVATION ANALYSIS

PRESENT SITUATION «BUBBLE» DETACHMENTS ON EXTERNAL LAYER

HIGHLY PROBABLE... FUTURE EVOLUTION

CNR – Istituto «E. Caianiello»
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IN THE LABORATORY PRACTICE
A LONG TIME IS REQUIRED
FOR REACHING MECHANICAL
STABILITY
AND THERMAL EQUILIBRIUM
OF THE PAINTING

HOURS TO OBTAIN
ACCURATE
INTERFEROGRAM
ON A LARGE AREA

SPEEDING-UP
MEASUREMENTS

LOCAL HEATING
INSTEAD OF
GLOBAL HEATING

REAL-TIME
FRINGE RECORDING
DURING THE
COOLING STEP

REAL-TIME MOVIE
FRINGE RECORDING
DURING THE
COOLING STEP

«TRAVELLING» FRINGES
TRACE
THE PATH OF DAMAGES

50 W BULB
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50 W LIGHT BULB

LOCAL TEMPERATURE INCREMENT 2,4 °C

10 SECONDS IRRADIATION

FRAMES EXTRACTED FROM THE REAL TIME MOVIE

REAL-TIME MOVIE

«TRAVELLING» FRINGES TRACE THE PATH OF CRACKS ON THE PICTORIAL LAYER

CRACKS DETECTED BY ESPI

PARTIALLY VISIBLE

VISIBLE

NOT VISIBLE

(BY VISUAL INSPECTION)
Characterization of hidden defects of an original XVI century painting on wood by ESPI (Electronic Speckle Pattern Interferometry)

50 W LIGHT BULB
5 SECONDS IRRADIATION
LOCAL TEMPERATURE INCREMENT 2,1 °C

50 °C LIGHT BULB

«TRAVELLING» FRINGES TRACE THE PATH OF CRACKS ON THE PICTORIAL LAYER

FRAMES EXTRACTED FROM THE REAL TIME MOVIE

VISIBLE
NOT VISIBLE
(BY VISUAL INSPECTION)
CONCLUSIONS

ESPI IS A HIGH VALUABLE DIAGNOSTIC TOOL FOR ART DIAGNOSTICS IN CHARACTERIZING DAMAGES OR REVEALING HIDDEN DEFECTS AT THE MOMENT THIS TECHNIQUES NEEDS AN EXPERT IN OPTICS. IT IS ESSENTIAL A CLOSE CO-OPERATION BETWEEN ART CONSERVATORS AND SCIENTISTS FOR ART CONSERVATORS IT IS PARTICULARLY IMPORTANT TO PERFORM ITERATIVE ANALYSIS AT REGULAR TIME INTERVALS TO ASSESS THE DAMAGE EVOLUTION.

REDUCTION OF THE COST AND SIMPLIFICATION OF MEASUREMENT METHOD… COULD ALLOW FOR A ROUTINELY UTILIZATION BY ART CONSERVATORS

Characterization of hidden defects of an original XVI century painting on wood by the ESPI (Electronic Speckle Pattern Interferometry) method

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