Applications of laser light in the field of Cultural Heritage (CH) are still more frequent and diversified. On one hand there are the ones made possible by the high spectral radiance of some laser types, for example the cleaning of lithoid materials by local heating and/or chemical modifications. On the other hand the substantial spectral and spatial radiation coherence gives rise to various holographic and interferometric methods

Holographic recording can be used to build up three-dimensional image archives of museum finds, which are useful for study and cataloguing purposes, but also for public display of particularly valuable or frail finds. The other chief field is the holographic interferometry, including a wide class of methods of non-destructive analysis and diagnostic techniques commonly employed in scientific and industrial fields.

These methods meet the requirements imposed by artwork diagnostics: the typical interferometric sensitivity puts in evidence small imperfections – e.g. small cracks or detachments on the surface of painting or frescoes – by applying only very small stresses which are absolutely safe for artwork objects (sometimes it is enough the environmental natural thermal drift).

Among the various interferometric techniques, a particular relevance in the CE field takes on ESPI (Electronic Speckle Pattern Interferometry). The object under investigation, suitably lighted by the laser light, originates a speckle field whose intensity distribution in the focal plane of a collecting lens is digitally acquired by a CCD or CMOS sensor connected to a computer.

Two different speckle patterns, corresponding to the two object states – “before” and “after” the deformation due to some external stress – are numerically combined, added or subtracted, and this operation gives rise to a virtual interference pattern.

Regions on the object surface not subject to deformation or displacement give rise to field distributions which are mutually coherent, showing, when a sum is made, a high contrast speckle pattern (i. e. a distribution with a large difference between the intensity of the bright and dark points; in jargon: a well developed pattern). Vice versa, displaced regions correspond to incoherent distributions and low contrast speckle patterns. When the patterns are subtracted the not-displaced regions give (theoretically) dark fringes and the displaced ones to low contrast patterns.

In both cases defects are put in evidence by closely spaced fringes or pattern’s discontinuity.

Two main different experimental arrangements are possible. In the first one two coherent light beams are used to illuminate the object, whose diffused light is sent to the detector. This arrangement is sensitive to displacement orthogonal to observation direction (transverse sensitivity). In the other arrangement only one beam lights the object whereas the second beam is sent directly onto the detector. This system detects displacements in the observation direction (longitudinal sensitivity). A configuration can be converted in the other one with only minor apparatus changes.

The main advantage of ESPI technique lies in the possibility of in situ usage, fulfilling an essential requirement for CE applications. It can be employed in preliminary planning of restoration operations and, subsequently, in order to evaluate the effectiveness of interventions.

The present-day optoelectronic techniques help in obtaining an instrument suitable for these purposes. The light source is usually a thermally stabilized laser diode whose output is launched into a single-mode optical fibre system which includes a beam-splitter. The detector is a small light-weighted digital camera connected to a personal computer.

Commonly the analysis of interference patterns needs numerical elaborations to improve contrast and to reduce the speckle pattern noise. On the contrary of what happens in scientific or industrial applications, where it is necessary to measure the exact amount of displacements, in the CE field it is enough a qualitative information on the defect’s presence, so it is unnecessary to solve the problem of phase wrapping, i. e. the indistinguishable appearance of patterns whose phase differs by 2n multiples.

Much more important are the consequences of the object local properties on intensity and polarization of the diffused light which can affect detector’s dynamical range and the visibility of fringes.

The present research is aimed to set up a laboratory ESPI interferometer in order to study in a systematic way the behaviour as a function of physical parameters (light intensity, polarization, shutter’s aperture and acquisition time,..).

Various materials, similar to the ones employed in the more common artworks, will be used.

Nevertheless, an important part of the research is studying suitable algorithms for image processing. Some numerical techniques – among which filtering by FFT, local averaging and wavelet transforms filtering – will be considered.

At present are under examination some preliminary data obtained by a two-beam interferometer working at the Luminescence Dating Laboratory (LDL) that put at disposal the most part of equipments.

RESEARCH TEAM

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