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Dynamic IRT for the frescoes assessment, the study case of Danza Macabra in Clusone (Italy)

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Abstract

IRT technique has various applications for the detection of the plasters defects in historic buildings, as well documented by the scientific literature in the last decades[1]. Most of the analysis is performed in transient condition, during and after the heating of few cm of the masonry exterior layer. Natural or artificial sources of heating successfully generate the convenient thermal gradient for detecting delaminations, cracks, the masonry texture under beneath the plaster and mapping damp areas. Nevertheless, local non-homogeneities of the surface temperature can be caused by the differences of heating absorption due to the optical and thermal characteristics of the surface and its decay. For example, the chromatic alterations, black crusts, salts, and, on the other hand, the colors of frescoes and decoration, the materials of the tiles of mosaics and their embedding cause localized variation of the temperature pattern.

Previous studies[2] demonstrated the advantages of tomographic techniques for obtaining a quantitative approach of IRT on plaster. In such a way the dynamic measures of IRT, versus time and the maximum value of thermal contrast, allow to locate the delamination and calculate its volume inside the thickness of masonry. The

[1] P. Bison, M. Dezzi Bardeschi, E. Grinzato, T. Kauppinen, E. Rosina, G.Tucci, *Infrared Thermal Scanning as a Methodology for Survey of Facades Palazzo della Ragione, Milan, Italy* Thermosense XVIII-An International Conference in thermal sensing and imaging, diagnostic applications, Orlando USA 1996

G. Schirripa Spagnolo, G. Guattari, E. Grinzato, P.G. Bison, D. Paoletti, D. Ambrosini, *Frescoes Diagnostics By Electro-Optic Holography And Infrared Thermography*, NDT.net - January 2000, Vol. 5 No. 1

E. Rosina, E. Grinzato and E. Robison *Mapping Masonry Bonding by Quantitative IR Thermography***,** Thermosense XXIV-An International Conference in thermal sensing and imaging, diagnostic applications, Orlando USA 2002

[2] V. Vavilov, P.G. Bison, C. Bressan, E.Grinzato, S Marinetti, *Some new ideas in dynamic thermal thermal tomography,* QIRT 1992

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procedures can be applied also in the field, often at boundary condition out of control (for example the without a constant irradiating energy)[3].

Starting from the experiences already set, the authors goal is to compare the IRT measures obtained at different boundary conditions on a famous fresco of Danza Macabra in Clusone, and to define the link between different kinds of material damages and the expected dynamic thermal results.

The Danza Macabra fresco is one of the most famous medieval external paintings in Europe, regarding the theme of the triumph of the death.

Among 1451 and 1485, the painter Jacopo Borlone, a well know professional in Bergamo area, decorated the interior of the meetinghouse of the Disciplini brotherhood and the external plaster of the northern façade. The building is part of a complex, built nearby the cathedral, in the upper part of the village, over a river. In 1575, the members of Disciplini brotherhood substantially began to change the interior displacement of the rooms: the major damage for the fresco was caused by opening a door at the first floor, and adding an external ladder.

The external ladder lasted until 1868, when some work provided the survival of the fresco: the addition of prominent eaves, to avoid running rainwater over the surface, and a new path to get the first floor.

In 1998 the entire complex got under restoration, starting from the Danza Macabra fresco. IRT has been an important tool for studying the decay and the information kept by the masonry under the plaster.

A complete report of the restorators allows defining exactly the maps of strengthening, water repellent, and others products applied on the surface. For that, it has been achieved the comparison between the results of IRT dynamic tests and the assessment of the surface.

The authors shot the first set of measures in 2000, at steady state condition; the second set consists of five recaptures shot within three hours after the end of direct solar irradiation, in the fall 2003.

Preliminary tests on frescoed surfaces, both in laboratory and in the field, showed that the measures during the heating phase are not reliable for the diagnosis of the damage, even using Long Wave

[3] E.Grinzato C.Bressan A.Mazzoldi, *The quantitative IR thermography for the diagnosis of frescoes*, Atti Fondazione Ronchi vol 1-3,1998

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thermocameras. In fact, the detectable thermal signal results from the interaction between the most external layer and the irradiation, and it is not enough representative of the heating flux coming from the inner layers of the plaster and masonry.
The effects due to the heat, which flows across these layers, are not prominent if compared with the ones caused by the interaction between surface and irradiation. Moreover these effects are lower than the noise due to the approximation of the spectral coefficient value. The authors already showed[4] that the multispectral evaluation of the reflectance coefficients in the range of visible and near IR contribute to a proper evaluation of the thermograms shot on frescoes, and, generally, surfaces affected by chromatic alterations. In the examined case the evolution of the surface temperature in time allows to quantify the effects of spectral absorption (absorbance) in the thermograms.
Particularly, in temperature evolution, the heating phase permits to identify the effects of optical absorbance and the cooling phase allows visualizing the inner structures, hidden by plaster, and locating the surface decay.
Comparing the thermograms to the maps of the applied restoration products, and the assessment before and after the restoration, it has been possible to correlate the materials and its state of conservation to the evolution of the thermal profile corresponding to each analyzed area.
The superimposing of the map of the time of maximum contrast and decay/interventions allows to map the different times of heating flux from the surface, and connect the cooling time with the different damage.

Key words: Plaster, stone, lime mortar, acrylic strengthening, IRT dynamic techniques

[4] N. Ludwig, E. Rosina, *Chromatic Alteration of Ancient Buildings Brick in Infrared Thermographic Analysis*, International Symposium Non-destructive Testing in Civil Engineering (NDT-CE), Berlino, 1995

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