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Università de L'Aquila

11th International Workshop on Advanced Infrared Technology and Applications

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September 7-9, 2011
Faculty of Science
University of L'Aquila, Italy

Fondazione "Giorgio Ronchi", Firenze
CNR-ITC, Sez. di Padova
CNR-IFAC "Nello Carrara", Firenze
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CREO, L'Aquila
Università de L'Aquila

11th International Workshop on

Advanced Infrared Technology and Applications

ABSTRACT BOOK

September 7-9, 2011
Faculty of Science
University of L'Aquila, Italy

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AITA 2011 PROGRAM

Wednesday, September 7

09.15 *Opening Session*
L. Ronchi Abbozzo, G.M. Carlomagno, C. Corsi, E. Grinzato, I. Pippi, O. Salvetti, S. Santucci, M. Strojnik

Advanced Sensors, Chairman: **G.M. Carlomagno**

09.30 **C. Corsi** (*invited lecture*)
Infrared: a key technology for security systems

10.10 **V. Grossi, S. Santucci, M. Passacantando**
Photoconductivity and Optical Response of MWCNT Devices

10.30 **M. D'Acunto, D. Moroni, O. Salvetti**
Single Molecule Detection based on Near-Infrared Sensors

10.50 *Coffee Break*

Advanced Sensors, Chairman: **S. Santucci**

11.20 **H. Zogg** (*invited lecture*)
Mid-Infrared 3-5 um Continuously Tunable Single Mode VECSEL for Gas-Spectroscopy

12.00 **C. Corsi, A. Dundee, P. Laurenzi, N. Liberatore, D. Luciani, S. Mengali , A. Mercuri, A. Pifferi, G. Tosone, R. Viola, D. Zintu**
Chemical Warfare Agents Analyzer based on low cost, room temperature, Infrared microbolometer Smart Sensors

12.20 **P. Carelli**
A fast compact THz spectrometer

12.40 **N. Liberatore, D. Luciani, S.Mengali, R. Viola**
Detection and identification of illicit drugs and precursors by IR absorption spectroscopy and gas chromatography

13.00 *Lunch*

Thermo-fluid-dynamics, Chairman: **J. Morikawa**

14.30 **G.M. Carlomagno** (*invited lecture*)
Flow Field and Heat Transfer in a Rotating U Channel

15.10 **M. Imbriale, A. Ianiro, G. Cardone, G.M. Carlomagno**
Heat transfer in jets impinging on airfoil leading edge region for anti-icing purposes

Advanced Technology and Materials, Chairman: **D. Balageas**

15.30 **P. Madejczyk, W. Gawron, J. Wróbel, S. Krishna, A. Rogalski** (*invited lecture*)
Thermoelectrically cooled MWIR InAs/GaSb Superlattice Photodiodes

16.10 **M. Imbriale, C. Caramiello, G. Cardone, G.M. Carlomagno**
Ceramic shell thermo-physical properties measurement for investment casting

16.30 **E. Pieczyska, R. Maciak, J. Luckner**
Infrared imaging of ferromagnetic NiFeGaCoSMA single crystal subjected to subsequent compression cycles

16.50 **J. Tesar, P. Vacikova and O. Soukup**
Infrared camera analysis of laser hardening

17.10 **C. Toscano, C. Meola, M. Iori, G.M. Carlomagno**
Porosity and inclusion detection in CFRP by infrared thermography

17.30 *Coffee Break*

Industrial Applications, Chairman: **O. Salvetti**

18.00 **P. Bison, E. Grinzato**
Emissivity measurement of semitransparent textiles

18.20 **M. Marchetti, M. Moutton, S. Ludwig, L. Ibos, J.-P. Monchau, V. Feuillet, J. Dumoulin**
Improvements and limits in the use of an infrared camera for pavement thermal mapping

18.40 **M. Svantner, P. Vacikova, M. Honner Grant**
Noncontact charge temperature measurement on industrial continuous furnaces

Thursday, September 8

Image Processing and Data Analysis, Chairman: **A.Rogalski**

09.00 **D. Balageas** (*invited lecture*)
In Search of Early Time: An original approach in the thermographic identification of thermophysical properties and defects

09.40 **M.T. Ahmed, C. Ibarra-Castanedo, A. Bendada, X. Maldague**
Wavelet based de-noising method for pulsed phase thermography

10.00 **M. Strojnik, G. Paez, A. Ortega**
Bi-spectral imaging in mid-IR at 1000 frames per second

10.20 **M. D'Acunto, D. Moroni, O. Salvetti**
Near-infrared spectroscopy for functional studies of brain: a challenge for BOLD model

10.40 **A. Merla, D. Cardone, L. Di Carlo, L. Di Donato, A. Ragnoni, A. Visconti, G.L. Romani**
Noninvasive system for monitoring driver's physical state

11.00 *Coffee Break*

Remote sensing and astrophysics, Chairman: **G. Paez**

11.30 **P. Coppo, L. Chiarantini, L. Alparone**
End-to-End Performance simulator for trade-off studies of vnir-swir imaging optical payloads

11.50 **A. Merla, L. Di Donato, M.L.Rainone, M. Di Fazio, P. Greco, P. Signanini**
Inspection of solid wastes landfill by means of aerial differential infrared thermography

12.10 **A. Barducci, D. Guzzi, C. Lastri, P. Marcoionni, V. Nardino, I. Pippi**
Emissivity and temperature retrieval using maximum entropy probability distribution

12.30 *Lunch*

Cultural Heritage, Chairman: **I. Pippi**

14.30 **G.Paez, M. Strojnik, A. Ortega** (*invited lecture*)
Near-IR illumination sources to determine invisible images on old paintings

15.10 **C. Ibarra-Castanedo, S. Sfarra, X.Maldague**
Infrared vision inspection of cultural heritage objects from L'Aquila city and its surroundings

15.30 **F.Albertin, L.Boselli, M. Gambaccini, E. Peccenini, V.Pellicori, F. Petrucci, F.Tisato**
Wide band IR reflectography

16.00 *Coffee Break*

Buildings and Infrastructure, Chairman **C. Maierhofer**

16.30 **E. Grinzato** (*invited lecture*)
Structural investigation of buildings by IR thermography: the case study of Aquila earthquake, 2009

17.10 **F. B. D. Djupkep, X. Maldague, A. Bendada, G. Ferrarini, P. Bison, E. Grinzato**
Room Air Movement Analysis by IR Thermography

17.30 **S. Caglio, V. Redaelli, M. Gargano, N. Ludwig, E. Rosina**
The surfaces of contemporary architecture: characterization of clinker by IRT

17.50 **L. Barazzetti, E. Rosina, M. Scaioni, M.I. Alba, M. Previtali**
A new IRT-photogrammetric procedure for 3D rendering

18.10 **A. Bortolin, G. Cadelano, G. Ferrarini, P. Bison, E. Grinzato**
Measurement of thermal performances of radiant heating systems by IR thermography

20.00 *Social Dinner*

Friday, September 9

Surface and Interface Thermal Analysis, Chairman: **E. Grinzato**

09.30 **J. Morikawa, E. Hayakawa, T. Hashimoto** (*invited lecture*)
Two-dimensional thermal analysis of organic and polymeric materials with cooled and un-cooled infrared cameras

10.10 **V. Joshi, K. Balasubramaniam, R.V. Prakash**
The thermomechanical behaviour of friction stir welded AA 5083 under uniaxial loading by infrared thermography

10.30 *Coffee Break*

Non Destructive Evaluation, Chairman: **H. Zogg**

11.00 **C. Maierhofer, M. Röllig, H. Steinfurth, M. Ziegler, M. Kreutzbruck, C. Scheuerlein, S. Heck** (*invited lecture*)
Comparison of different infrared camera systems and excitation strategies for testing of solder connections

11.40 **C. Meola, G.M. Carlomagno, C. Bonavolontà, M. Valentino**
Monitoring composites under bending tests with infrared thermography

12.00 **W.Swiderski, V.Vavilov**
Studying the phenomenon of composite transparency in thermal NDT

12.20 *Discussion & Closing Session*

13.00 *Lunch*

15.00 *Visit to L'Aquila Old Centre*

Abstracts

Infrared: a key technology for security systems
(invited)

Carlo Corsi

C.R.E.O., L'Aquila -Italy

Infrared Science and Technology has been, since the first applications, mainly dedicated to Security and Surveillance especially in military field, besides specialized techniques in thermal imaging for medical diagnostic and building structures and recently energy savings and aerospace.

Till recently the Security applications were mainly based on thermal imaging as Surveillance and Warning military systems. In all these applications the advent of room temperature, more reliable due to the coolers avoidance, low cost and, overall, completely integratable with Silicon technology FPAs, especially designed and tailored for specific applications, Smart Sensors has really impacted with revolutionary and new ideas and system concepts in all the Infrared fields, especially for Security applications.

Lastly, the advent of reliable Infrared Solid State Laser Sources, operating up to the Long Infrared Wavelength Band and the new, emerging techniques in Far Infrared SubMillimeter TeraHertz Bands has opened wide and new areas for developing new, advanced security systems.

A review of all the items with evidence of the weak and the strong points of each item, especially considering possible future developments, will be reported and discussed.

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Photoconductivity and Optical Response of MWCNT Devices

V. Grossi, S. Santucci, M. Passacantando

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We report photocurrent measurements derived by light excitation in different configurations exploiting sheets of Multi Wall Carbon Nanotubes (MWCNTs) grown by Chemical Vapour Deposition (CVD).

We have investigated photoconductivity properties of MWCNTs under ultraviolet, visible and near-infrared radiation. The spectral photoresponse of all devices increases with increasing photon energy and very interesting agreement is found between the trends of the photoconductance and the absorbance.

We study photoconductivity properties of MWCNTs in order to produce large area light sensors as well as optoelectronic nanodevices.

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Single Molecule Detection based on Near-Infrared Sensors

M. D'Acunto, D. Moroni, O. Salvetti

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Molecular detection using near-infrared light between 0.9 and 1.3eV has important environmental and biomedical applications because of greater light penetration into scattering media and reduced auto-fluorescent background from biological contaminants. Single Walled Carbon Nanotubes (SWNTs) have a tunable band-gap fluorescence in the near infrared that has been demonstrated to be sensitive to changes in their local dielectric function but remain stable to permanent photobleaching (Strano et al, 2006; D'Acunto et al, 2010). In addition, it has been reported the synthesis and demonstration of several types of solution-phase, near-infrared sensors by functionalizing carbon nanotubes with ligands designed to modulate the fluorescence in response to selective molecular binding.

This paper will focus the attention on the development of the current quasi-one-dimensional excitonic as observed on carbon nanotube photo-physics and describe a series of model sensor architectures that can be developed to built single-molecule sensors.

b-D-glucose sensors, optical detection modality via specific DNA sequences including single nucleotide polymorphism on the surface of solution suspended single-walled carbon nanotubes, and hybridization of a 24-mer oligonucleotide sequence with its complement produces a hypsochromic shift of 2meV, with a detection sensitivity of 6nM are the recognized example of the infrared fluorescence powerful biosensing activity in biological tissues.

In this paper we study the nonlinear time-resolved luminescence signals due to multiexciton recombination processes in SWNT both using theoretical efforts and ab initio simulation. Such phenomenon is the basic physical foundation for the development of small-scale biosensors scaling to single-molecule detection.

References

D'Acunto, Colantonio, Moroni, Salvetti, Journal of Modern Optics, 57(18), 1695-1699, 2010

M. Strano et al., Nanoletters, 6(3), 371-375, 2006

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Mid-Infrared 3-5 um Continuously Tunable Single Mode VECSEL for Gas-Spectroscopy

(*invited*)

H. Zogg, A. Khiar, M. Rahim, M. Fill, F. Felder, R. Rodriguez

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Novel single mode continuously tunable mid-infrared Vertical External Cavity Surface Emitting Lasers (VECSEL) are described.

They are realized with IV-VI narrow gap semiconductors. Emission wavelengths are 3-5 μm and tuning range >100 nm. The VECSEL emit in a narrow circular output cone and operate near room temperature.

They are simple to fabricate and ideal sources for high resolution mid-IR gas spectroscopy.

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Chemical Warfare Agents Analyzer based on low cost, room temperature, Infrared microbolometer Smart Sensors

C. Corsi, A. Dundee, P. Laurenzi, N. Liberatore, D. Luciani, S. Mengali, A. Mercuri, A. Pifferi, G. Tosone, R. Viola, D. Zintu

C.R.E.O., L'Aquila -Italy

Advanced IR emitters and sensors are under development for high detection probability, low false alarm rate and identification capability of toxic gases.

One of the most reliable techniques to identify the gas species is Absorption Spectroscopy, especially in the micron Infrared spectral range, where most of existing toxic compounds exhibit their strongest roto-vibrational absorption bands. Following the results obtained from simulations and analysis of expected absorption spectra, a compact non dispersive infrared multi-spectral system has been designed and developed for security applications.

It utilizes a few square millimeters thermal source, a novel design multipass cell, and a smart architecture microbolomeric sensor array coupled to a linear variable spectral filter to perform toxic gases detection and identification. This is done by means of differential absorption spectroscopic measurements in the spectral range of the mid-infrared.

Experimental tests for sensitivity and selectivity have been done with various CWA's gases and a multiplicity of Vapour Organic Compounds. Detection capability down to ppm has been demonstrated.

Possible improvements by means of open path or hollow-fiber-based sensor implementation are also presented and discussed for future systems evolution.

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Wednesday 7th, 12.20 – 12.40

A fast compact THz spectrometer

P. Carelli

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Here I present a fast spectrometer working in the 0.5-5 THz range of frequency. The detector is a fast superconducting bolometer. The filtering is made by 18 selective complementary surface filters fabricated on an aluminum film, set on a rotating silicon wafer. The typical measurement time is 10 seconds.

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Detection and identification of illicit drugs and precursors by IR absorption spectroscopy and gas chromatography

N. Liberatore, D. Luciani, S.Mengali, R. Viola

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We here report research activities and initial results obtained in developing DIRAC*, an advanced sensor system, that combines miniaturized Gas Chromatography (GC) as its key chemical separation tool, and Hollow-Fiber-based Infra Red Absorption Spectroscopy (HF-IRAS) as its keyanalytical tool to detect and recognize Amphetamine Type Stimulants, illicit drugs, illicit drugprecursors, and natural drugs (such as cocaine).

The sensor is being implemented as a rugged andhand-portable unit to be used primarily by customs officers for controls at EU frontiers and by lawenforcement units for intra-Community checks.

DIRAC foresees the development of a very compact IRAS module, wherein standard Fourier Transform InfraRed (FTIR)/light-pipe set up is replaced by solid state instrumentation. Use will be made of broadly tunable Quantum Cascade Laser sources (QCLs), and Photonic Band Gap IR hollow fibers. As such, the QCL is a quasi-monochromatic source, capable of delivering IR beams orders of magnitude more intense than the thermal emitter mounted in a standard FTIR system, and, scanning broad regions of the IR spectrum in a fraction of a second, with good uniformity and reproducibility.

Here, the laser beam is coupled into a hollow fiber which acts as a low loss optical cell of very small volume. Nano-grams of the analyte, when vaporized in that cell, maintain concentrations that are relatively high –parts per million, typically–, and anyhow larger than the system Limit of Detection (LoD).

* Project 'DIRAC', financially supported by the European Commission in the FP7 Programme.

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Flow Field and Heat Transfer in a Rotating U Channel

(*invited*)

G.M. Carlomagno

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A classical way to cool turbine blades is by *forced internal convection*. Usually, cold air from the compressor is supplied through the hub section into the interior of the blade and is discharged after flowing through a serpentine passage. The serpentine passage is made of several adjacent straight ducts, aligned spanwise, and connected by 180° turns, named *U turns*. The presence of these turns causes modifications of the flow pattern with consequent high variations of the convective heat transfer coefficient and thermal stresses in the blade wall.

The effects of rotation change strongly the thermo-fluid-dynamic behavior of the flow in a channel. This happens because *in a rotating channel* there is interaction between the following forces:

- *Coriolis forces*
- *Pressure gradients causing the flow in the main direction*
- *Centrifugal forces*

The resulting flow field is highly three dimensional and this affects the heat transfer coefficient distribution.

That is the reason why this problem is extensively studied from the thermo-fluid-dynamic point of view by means of both Particle Image Velocimetry (PIV) and InfraRed Thermography.

An experimental as well as a parametric study are developed to find an empirical correlation whose parameters provide the relative importance of the effects produced by the *wall normal velocity component* and by the *Turbulent Kinetic Energy* on the *Nusselt number* distributions.

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Heat transfer in jets impinging on airfoil leading edge region for anti-icing purposes

M. Imbriale, A. Ianiro, G. Cardone, G.M. Carlomagno

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An experimental investigation of heat transfer due to a row of air jets internally impinging on airfoil leading edge region surface is presented. Surface temperature distribution is measured with infrared thermography and rebuilt on the 3D airfoil leading edge surface. Heat transfer characteristics are then evaluated using a heat thin foil technique. The effect of high relative curvature is investigated by changing the jet nozzle diameter (impinging surface diameter remaining constant). Reynolds number, spacing between adjacent jets, jet exit to surface spacing and jet inclination are also made to vary.

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Thermoelectrically cooled MWIR InAs/GaSb Superlattice Photodiodes
(*invited*)

P. Madejczyk, W. Gawron, J. Wròbel, S. Krishna, A. Rogalski

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Department of Electrical and Computer Engineering, Center for High Technology Materials, University of New Mexico, Albuquerque, New Mexico 87106, USA

We report on temperature dependence characteristics of thermoelectrically cooled medium wavelength InAs/GaSb superlattice photodiodes. Bulk based model with the effective band gap of superlattice material has been used in modelling of the experimental data.

Temperature dependence and bias dependent dynamic resistance of the diodes have been analyzed in detail to investigate dark current contributing mechanisms that are limiting the electrical performance of the diode.

It is shown that superlattice photodiodes are dominated by diffusion current in temperature range 190–230 K; at lower temperature the photodiodes are limited by generation-recombination and tunnelling processes.

Finally, the type-II photodiode parameters are compared with performance of HgCdTe photodiodes. It is clearly shown that R0A product of type-II superlattice devices has reached a comparable level with the state of the art HgCdTe photodiodes.

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Ceramic shell thermo-physical properties measurement for investment casting

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An experimental technique based on unsteady IR thermography measurements is proposed to quickly evaluate ceramic shell thermo-physical properties.

A ceramic sample is heated up to about 1200°C and cooled in quiet air at ambient temperature while an infrared camera detects the time dependent surface temperature.

Applying the unsteady energy balance to a thin slab it's possible to evaluate ceramic thermal diffusivity, thermal conductivity, convective heat transfer coefficient and the product between density and specific heat.

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Infrared imaging of ferromagnetic NiFeGaCoSMA single crystal subjected to subsequent compression cycles

E. Pieczyska, R. Maciak, J. Luckner

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Experimental study of thermomechanical couplings related to pseudoelastic deformation of ferromagnetic shape memory alloy was presented. NiFeGaCo single crystal specimens were subjected to subsequent loading and unloading compression cycles.

The stress -strain parameters were recorded by both the mechanical and the laser extensometers. Fast and sensitive thermovision camera was used in order to record an infrared radiation from the specimen surface and calculate the temperature changes related to the exothermic martensite forward and endothermic reverse transformation.

Infrared techniques enabled us to record the initiation and development of the phase transformation. It was found that the stress and the temperature changes recorded in the subsequent cycles depend on the test conditions. The highest discrepancies were observed between the first and the second cycle.

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Infrared camera analysis of laser hardening

J. Tesar, P. Vacikova and O. Soukup

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Improvement of surface properties such as laser hardening becomes very important in present manufacturing. Resulting laser hardening depth can be affected by changes in optical properties of material surface i.e. by absorption coefficient that gives the ratio between absorbed energy and incident laser energy.

The surface changes on tested sample of steel block were made by engraving laser with different velocity and frequency. During the laser hardening the process was observed by infrared (IR) camera system that measures infrared radiation from the heated sample and depicts it in a form of temperature field.

The thermogram (image from the IR camera) of the sample is shown. Maximal temperatures of all engraved areas are evaluated and compared.

The highest and the lowest temperatures correspond to the highest and the lowest hardening depths.

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Porosity and inclusion detection in CFRP by infrared thermography

C. Toscano, C. Meola, M. Iori, G. Carlomagno

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The wide use of composite materials in the aeronautical industry has evidenced the need for development of even more effective Non Destructive Evaluation methodologies in order to reduced rejected parts and to optimize production costs.

Infrared thermography is one of the youngest used techniques, which can be employed in several different arrangements.

In this work, the capability of Lock-In and Pulse thermography to detect, in the transmission mode, slag inclusions and porosity was analyzed.

This was done by using Carbon Fibre Reinforced Polymers composite specimens specifically fabricated with induced defects. Both of the techniques were found definitely able to reveal the presence of defects such as porosity and inclusions (and delamination), moreover they could be considered complementary in order to better define the nature of the found defects.

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Emissivity measurement of semitransparent textiles

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In the textiles production industry it is more and more common to advertise new textiles, especially for sports wear, by claiming their ability to emit IR radiation in the long wave band at a higher degree with respect to normal clothes, that being highly beneficial to improve sporting performances.

Three textiles are compared, one normal and two 'special' with Ag+ ions and Carbon powder added, with different colors.

The emissivity of the textiles has been measured to determine if it is increased in the 'special' textiles with respect to the normal one. No substantial increase has been noticed.

Nonetheless, the test implied some non-standard procedure due to the semitransparent nature of the textiles, in comparison with the normal procedure that is commonly used on opaque surfaces.

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Improvements and limits in the use of an infrared camera for pavement thermal mapping

M. Marchetti, M. Moutton, S. Ludwig, L. Ibos,
J.-P. Monchau, V. Feuillet, J. Dumoulin

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Thermal mapping is a common technique to appreciate and to evaluate the ice susceptibility of a road network. It is usually obtained using an infrared radiometer on board of a dedicated vehicle. This paper presents the results of thermal mapping conducted with an infrared camera. The instrument clearly improved the measurement rate with respect to the conventional radiometer. Data analysis needed an emissivity distribution correction. A new winter risk index was built and was consistent with the infrastructure. A transverse winter risk was investigated too, to analyze the incidence of wheel tracks.

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Noncontact charge temperature measurement on industrial continuous furnaces

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Continuous furnaces are commonly used for steel slabs reheating before a rolling operation.

These furnaces are mostly gas-fired, their length can be a several tens of meters and the minimum charge temperature should be typically from 1100 to 1200 °C before the rolling mill entry.

Energy consumption and environmental impact of such facilities are significant and, therefore, an optimization of their operation is an important question. It is necessary to perform a number of measurements to s et-up of an optimization system correctly.

The direct charge temperature measurement procedure using infra-red detectors is introduced in this contribution. The most important problems of charge emissivity setting and ways of the emissivity determination are discussed. The measurement set-up is described and measured temperatures examples are shown.

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IN SEARCH OF EARLY TIME
An original approach in the thermographic identification of thermophysical properties and defects

(*invited*)

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Active thermography gives the possibility to characterize thermophysical properties and defects in complex structures presenting heterogeneities. The produced thermal fields can be rapidly 3-D.

On the other hand, due to the size of modern thermographic images, pixel-wise data processing based on 1-D models is the only reasonable approach for a rapid image processing.

The only way to conciliate these two constraints when dealing with time-resolved experiments lies in the earlier possible detection/characterization. This approach is illustrated by several different applications and compared to more classical methods, demonstrating that simplicity of models and calculations is compatible with efficient and accurate identifications.

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Wavelet based de-noising method for pulsed phase thermography

M.T. Ahmed, C. Ibarra-Castanedo, A. Bendada, X. Maldague

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The existence of hidden defects in a sophisticated system can cause very expensive and terrible damages.

Pulsed phase thermography (PPT) has been proved very efficient in order to detect hidden defects at various depths.

PPT is a signal processing technique for pulsed excitation method which incorporates the advantages of lock-in thermography. Phase images provide better depth inspection.

The introduction of blind frequency gives indication of frequencies where the defects appear and disappear using phase images. However, PPT results are affected by noise.

A wavelet based de-noising method is proposed in this work. The analytical solution of PPT is used in order to test the proposed technique which gives very promising results and might be very effective for real inspections.

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Bi-spectral imaging in mid-IR at 1000 frames per second

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We propose, evaluate, and demonstrate the performance of an IR/optical double-image experimental setupwhere we can capture two nearly simultaneous images of a single object, in two different spectral bands, using a single detector array.

With this arrangement, we may observerapidly-changing phenomena, at a rate of more than 1000 frames per second, without loss of the spatial information about the test subject.

We apply this techniqueto flame analysis in the mid-IR to determine the efficiency of burning (of butane and air mixtures).

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Near-infrared spectroscopy for functional studies of brain: a challenge for BOLD model

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The nonlinearity of blood oxygenation level-dependent (BOLD) response to stimuli of different duration (in a special way those of short duration) has been studied by functional magnetic resonance imaging (fMRI). This nonlinearity is assumed to be due to neural adaptation and the nonlinearity of the response in the oxygen extraction fraction (OEF).

Simultaneous measurements made with fMRI and near-infrared spectroscopy (NIRS) give the possibility to evaluate OEF response contributes for a large time scale. The hemodynamic response nonlinearity can be quantified using an impulse response function model with saturation nonlinearity scaling in the response amplitude, assuming that the unknown neural adaptation parameters vary with a physiologically feasible range.

In this paper, we adopt an inferential method for clarify the role of a set of unknown parameters on the nonlinearity BOLD model as measured by fMRI and NIRS.

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Noninvasive system for monitoring driver's physical state

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In this paper, we present a novel approach to monitor the driver' state and autonomic activity based on infrared imaging.

The proposed approach permits to monitor the breathing activity and rate, the blinking rate, the heart beat rate variation, plus the temperature fluctuations in facial regions of sympathetic interests.

The comparison of physiological data computed through thermal imaging with ground truth data shows that the proposed method is reliable and enough accurate for contact-less, noninvasive, and ubiquitous monitoring of driver's physical state.

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End-to-End Performance simulator for trade-off studies of vnir-swir imaging optical payloads

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A detailed instrument simulator is often used during the realization (B/C) and commissioning phases of a spaceborne/airborne payload to produce reliable data useful for testing the ground segment processors and the product algorithms.

In this paper, a simplified end-to-end software tool (ENVI-IDL environment) for simulation of optical instruments data based on synthetic/airborne hyper-spectral data has been developed and tested.

Such a simulator is conceived as a phase 0-A aid tool for the specification and early development of new Earth observation optical instruments. Their compliance to user's requirements is achieved through a process of cost/performance trade-off.

The proposed tool is based on three different core modules: the scenario, the instrument and the atmospheric simulators. High spatial/spectral resolution images with low intrinsic noise and the sensor/mission specifications carried out for PAN and VNIR-SWIR Hyperspectral optical sensors as initial studies to realized or on-going Selex Galileo projects for airborne (SIM-GA) and space-borne (HYPSEO as precursor of PRISMA) payloads.

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Inspection of solid wastes landfill by means of aerial differential infrared thermography

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Aerial differential thermal imaging has been proposed to characterize the ground temperature distribution of two solid wastes landfills. The differential approach permitted to detect regions with thermal abnormalities potentially associated with either biogas leakage and migration or improper landfill settlement and management. Methods, results, limits, and potentialities of the proposed approach are discussed.

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Emissivity and temperature retrieval using maximum entropy probability distribution

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Temperature – Emissivity Separation (TES) in the Thermal InfraRed (TIR) domain is an ill-posed problem, in which the number of measurements (the measured spectral radiances) is less than the number of the parameters to be determined (the values of emissivity in each channel plus the temperature).

In this paper we present a new theoretical method for deriving these parameters from a set of TIR data. The presented procedure determines both the spectral emissivity and the temperature by looking for their maximum entropy probability density function. Once that this density has been assessed, the expectation of the emissivity spectrum and the target temperature can be inferred.

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Near-IR illumination sources to determine invisible images on old paintings
(*invited*)

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Mexico possesses a large cultural heritage of paintings, elaborated after the European explorers encountered the New World.

The interest in documenting these treasures was renewed recently with the development of nondestructive remote techniques.

We examined an undocumented painting for presence of any invisible signatures and dates.

We employ several illumination-detection schemes, including IR broadband and LED arrays to achieve this purpose. We made visible the signature at 1 μm and the date with the LED illumination at 1.2 μm.

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Infrared vision inspection of cultural heritage objects from L'Aquila city and its surroundings

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The City of L'Aquila has a long history of catastrophic earthquakes. The last big earthquake causing enormous damage hit the City in April 2009.

The City is the home of a rich collection of artworks from the Romanesque, Gothic, Baroque and Renaissance styles. Cultural heritage in L'Aquila is undeniable and the use of nondestructive techniques is fundamental for assuring the integrity of this valuable objects.

The goal of this study is to assess the performance of infrared vision techniques, infrared reflectography and active infrared thermography, for the inspection of cultural heritage objects from L'Aquila.

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Thursday 8th, 15.30 – 15.50

Wide band IR reflectography

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In this work a scanning device of IR reflectography and its application on artworks is presented. Two detectors are used covering different spectral ranges, from the visible limit up to 3500nm, attempting to detect the underdrawing in paintings of 15th and 16th century, characterized by dark backgrounds and low contrast.

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Structural investigation of buildings by IR thermography: the case study of Aquila earthquake, 2009

(*invited*)

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The identification of architectural structures hidden by the finishing layer on buildings is a mature and important application of IR thermography [1,2]. Both for energy saving purposes and for static analysis, e.g. it is important identifying and measure the location and extension of reinforcing beams, made by iron or reinforced concrete. Another issue is the discovering of modifications of the building that sometime have been not recorded or lost along the time, as in the case of heritage buildings.

A new emerging field where IR thermography proved to be very effective is the evaluation of the seismic risk [3,4].The paper reports a structural survey conducted post-earthquake,basedon IR Thermography applied to cultural heritage. The earthquake happened in Abruzzo (Italy) the 2009, April the 6thkilled about 300 people. Furthermore, many works of art have been almost destroyed or are in a great danger of collapse. Monuments carrying centuries of history, Important buildings, like Churches, palaces or castles, in the city of Aquila or smaller villages nearby needs to be quickly restored, but first of all checked. Unfortunately, not only human beings, but even precious frescoes must be evaluated in order to be saved. The emergency needs faster, safer and reliable tools than now available.

IR thermography has been found very valuable for this purpose, due to his optical nature. Anew theory underlies successfuldetection by thermography of structural cracks affecting the building masonry, not detectable using visual inspection. Experimental results are shown, taken just 20 days after the earthquake that stroke Aquila (Italy).

A robust technique for the non-destructive testing and evaluationhas been set up rapidly. The S. Lucia abbey has been monitored to evaluate the structural conditions of the wall and the fresco itself (Giotto's school XIV century). The figure 1 clearly shows many structural cracks and the fresco lack of adhesion in several points. It is forth saying the transient technique adopted required just 3 hours to monitor the whole buildings and the processing of hundreds of thermograms has been carried out using other 3 hours. After that, the day after the authority decided the best emergency intervention to save the monument.

It is important to stress that the key point of the success is the tight integration of knowledge between structural engineers and thermography experts.

The same approach can be spoiled for the assessment of structural integrity of buildings, aided by IR Thermography. In such a way, a preventive seismic risk is assessedsistematically in seismic areas. Starting from single images and sequences,

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combined both in time or space, according to dedicated algorithms, some parameters very useful to evaluate masonrycan be extracted. The seismic risk of a building is much more cost effectively and extensively derived using such a data as input for the model than the traditional partially destructive tests.

It is quite impressive to notice the correlation between week points indicated by thermography, before the earthquake and the collapsed parts. The picture 2 gives another example taken from the church of S. Stefano in Sessanio (AQ, Italy) last year and today.

The last example is the survey of the very large Collemaggio monastery (nowadays used as music school) carried out before and after the earthquake, in a single day.

Such results indicate a new field of application of IR thermography as a valuable contribution in case of earthquake. This approach could be effectively applied to several other buildings in danger.

As a confirmation of the method experimental results reported one year before the earthquake. It is impressive to compare such a results with the damage undertaken by the buildings.

References

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Room Air Movement Analysis by IR Thermography

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Trying to evaluate the indoor thermal comfort by means of infrared thermography, one needs to know the temperature and the velocity of air. In this work we attempt to measure air stream velocity by means of infrared thermography. The principle adopted here is similar to the hot-wire anemometer. That is the correlation between the air speed and the heat lost by the wire during its cooling. In transient regime, hot/ cold air is injected in the room. We use special targets and for each, we measure the time temperature variation. We can then compute the convective heat transfer coefficient during the transient phase. Knowing the calibration relation of the target, that is the functional relation between the convective heat transfer coefficient and the air velocity, we are then able to map the 2D velocity magnitude of air.

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The surfaces of contemporary architecture: characterization of clinker by IRT

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The researchers focus on the IRT procedure of heat transmittance measures in ceramics finishing materials of contemporary architecture. The aim of the research is the development of a method for the thermal characterization of clinker, a very common ceramic finishing material of buildings. The first experimental phase was performed in laboratory on clinkers of different shapes, thickness, colors, and glazing surface. The researchers determined two characteristic parameters related to thickness and thermal conductivity, by the interpolation of the heating curve in function of time with an analytical curve (resulted from a particular solution of Fourier's equation). This curve allows to obtain a specific parameter characteristic of the material under investigation for any specimen. At present the researchers are studying the correlation between this parameter and the damage level of the specimens; they are testing the model on real scale study cases in the second experimental phase.

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A new IRT-photogrammetric procedure for 3D rendering

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The authors have developed a new 3D acquisition and processing procedure to allow quantitative data analysis with a combination of both visible and thermal imaging techniques, which maps 2D thermographic images onto a 3D model.

The combination of laser scanning survey, photogrammetric imagery and IRT allows the generation of three- dimensional thermal data useful for localization, visualization, and analysis of small anomalies such as delamination of finishing tiles in contemporary architectures.

The paper shows the methodology and its experimental application to the Trifoglio building in the main campus of Politecnico di Milano University, within the applied research for the plan of conservation and maintenance of the campus' buildings.

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Measurement of thermal performances of radiant heating systems by IR thermography

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A wide climatic chamber allows measuring the power delivered by a radiant heating module by IR thermography or traditional methods. Tests are combined with mathematical simulation in order to evaluate the thermal performance and optimize the system. A test facility is set up for measuring the performance of a real scale heating floor dedicated to industrial environment. An automated device coupled with an IR camera enables to collect data. Thermal images are processed with an ad hoc algorithm in order to correct geometrical distortion and produce temperature profiles, radiometrically corrected IR panorama views and heat flux distribution.

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Two-dimensional thermal analysis of organic and polymeric materials with cooled and un-cooled infrared cameras

(*invited*)

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Application of micro-scale thermal imaging methods to the materials thermal-property characterization is presented with main two topics. The first objective is to measure the anisotropic thermal diffusivity of micro-structured polymer films using a modulated laser-diode spot heating at different frequencies. The analysis is based on the computational phase lock-in system for the temporal evolution extracted from the sequence of infrared image. The second one is to present the emissivity corrected thermal imaging using a real time direct impose-signal system on the phase transitions of polymeric spherulite, organic molecular crystals, and the biological cells. It enables to visualize the exothermic latent heat of freezing cells at a minus temperature. The applicability of un-cooled micro-bolometer (thermal detector) to the micro-scale thermal analysis on phase transitions is discussed in comparison with the photon detector.

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The thermomechanical behaviour of friction stir welded AA 5083 under uniaxial loading by infrared thermography

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The Friction stir welding (FSW) is a new and promising welding process which is used for joining difficult to weld material such as Al-alloy and dissimilar material. Welds made by FSW are shown to have much improved mechanical properties than the corresponding fusion welds. The yield strength and stress-strain behavior of the AA 5083 is studied using the concept of thermomechanical effect. The experimental results shows that the cooling occurs in elastic region while heating occurs in the plastic region and the point of inversion coincides with the yield strength of material. Determination of the mechanical properties such as yield strength and stress-strain behavior by using thermomechanical concept is an alternate way to 0.2% offset method of determining the yield strength and which is more reliable.

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Comparison of different infrared camera systems and excitation strategies for testing of solder connections

(*invited*)

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Data recorded with a cooled InSb quantum detector IR camera and a microbolometer IR camera are compared for testing of prototype Cu solder connections containing connection faults.

For thermal excitation, impulse thermography using flash lamps and lock-in thermography using halogen lamps was applied. Additionally, an LED array was tested enabling higher excitation frequencies in lock-in mode as halogen lamps.

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Monitoring composites under bending tests with infrared thermography

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The attention of the present paper is focused on the use of an infrared imaging device to monitor the thermal response of composite materials under cyclic bending. The specimen surface displayed temperature variations pursuing the load variations with cooling down under tension and warming up under compression; such temperature variations are in agreement with the bending moment. It has been observed that the amplitude of temperature variations over the specimen surface depends on the material characteristics. A defect inside the material affects the temperature distribution with deviation from the usual bending moment trend.

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Studying the phenomenon of composite transparency in thermal NDT

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In thermal non-destructive testing, it is typically assumed that composite materials are optically-opaque for both the optical heating radiation and the infrared radiation emitted by tested objects. As a result of this study, it has been demonstrated that some composites, such as carbon and glass fiber reinforced plastics and others, are partially transparent for heating radiation, therefore, this phenomenon must be taken into account when determining thermal method detection limits.

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