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Integration of thermal and hyperspectral VNIR imagery for architectural and artistic heritage analysis and monitoring

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The application of integrated hyperspectral VNIR and thermal data for analyzing and monitoring the architectural and artistic heritage status is becoming a remarkable tool to be combined with other non-destructive techniques (e.g. GPR), and prior to destructive checking, in order to extract appropriate information and make useful decisions [1].

As the analysis of some kind of damages (e.g. water infiltrations) or alterations is not always fulfilled with visible and thermographic imagery, the proposed study aims at integrating hyperspectral reflectances and temperature and apparent thermal inertia behaviours. Hyperspectral data is able to discriminate materials on the basis of their different patterns of wavelength-specific absorption; in fact, they are successfully used for identifying minerals and rocks, as well as detecting soil properties including moisture, organic content and salinity [2]. Moreover, the potential to find out alterations or damages and monitoring them through non-destructive sensors is particularly appreciated in structural analysis for restoration works such as water infiltrations in outdoor cultural assets and moisture penetration in a wall that is a major source of paint alteration [3, 4].

The jointly use of the reflective and infrared (emitted, absorbed, reflected and transmitted) radiation for this research study is encouraged by the technical and operative characteristics of the observation systems at disposal that can provide high spectral resolution and high-frequency images with low NeΔR e NeΔT values and able to observe the variables and physical and optical parameters in quasi real-time and connected to the cultural heritage status. The following portable field instruments are used for this study: (a) HYSPEX hyperspectral scanner working in the VNIR (0.4-1.0μm) spectral region, which is an imaging spectrometer with a very high spectral and spatial resolution, (b) 2 FLIR SC7000 Thermal cams working in the MWIR (3-5 micron) and LWIR (8-12 micron) spectral regions provided with a portafilter and specific spectral filters, and (c) ASD-FieldSpec FR Pro spectroradiometer, a portable hyperspectral device operating in the 350-2500 nm spectral range (see characteristics in Table 1).

This paper shows the preliminary results after using visible near infrared hyperspectral and thermal infrared integrated imagery for detecting and monitoring the conservation status of some examples of Italian architectural and artistic heritage. The integration of the in situ thermographic imagery with the hyperspectral scanner imagery allowed us to increase the knowledge of alterations in the examined structures, e.g. invisible moisture shapes due to water infiltration and processes of detachment.

The proposed monitoring approach can be also useful to individuate suitable parameters which will allow a continuous and/or remote control of the condition of architectural and artistic heritage to plan appropriate interventions for their conservation.

Table 1. Characteristics of sensors used for the study.

	Spectral Region	Spectral Resolution	Spectral Range	IFOV
Hyspex VNIR-1600	VIS-NIR	3.7nm	$0.4 \div 1.0 \mu$m	0.75 mrad
FLIR SC7900-VL	MWIR	integrated	$3.5 \div 5.0 \mu$m	1.2 mrad
FLIR SC7000	LWIR	integrated	$7.7 \div 11.5 \mu$m	2.4 mrad
FieldSpec FR-Pro	VIS-NIR-SWIR	3 nm @ 700 nm 10 nm @ 1500 and @2100 nm	$0.35 \div 2.50 \mu$m	$1 \div 25$ degree

1 References

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