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Pulse Phase Thermography for Panel Paintings Inspection in Mid-wave and Long-wave Infrared Bands.

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Abstract:

Active infrared thermography has demonstrated an ability to retrieve critical sub-surface level information relevant to historical conservation efforts aiming to better understand and preserve multi-layered panel paintings. Complementary use of two Telops infrared cameras (Mid and Long Wave IR), a pulsed thermography system, and pulsed phase thermography processing software, has shown an ability to detect underlying drawings and pentimenti [1]. Further developments on this work have now shown an ability to detect structural components in situ, and preparatory surface irregularity across canvas layers. This non-destructive approach provides critical information to art preservationists and should be considered for broader adoption.

1. Introduction:

Applications of active thermography, particularly pulsed phase thermography (PPT) have demonstrated an ability to assist historical conservation efforts which aim to better understand and preserve cultural heritage artwork. In addition to being a non-destructive and non-contact technique, key benefits of this approach include visualization of otherwise hidden features such as under-drawings and pentimenti, or defects like previous structural repairs, cracking, and adhesive compound applications [1][2]. Employing two Telops infrared cameras, (Mid and Long Wave IR) and a pulsed thermography system, collections completed at the Louvre Museum in collaboration with C2RMF (Centre de Recherche et de Restauration des Musées de France) have proven effective in in their ability to reveal and identify otherwise undetectable components and features.

2. Materials and Methods:

An oil painting provided by C2RMF was analyzed by an active pulse phase thermography (PPT) setup consisting of two flash lamps, and two high-speed infrared cameras. The painting is 26cm x 32cm 18th-century original which depicts town nestled upon a bridged waterway. Specifically, an area in the bottom right of the painting was focused upon due to the presence of an otherwise undetectable pentimenti feature resembling a tower structure. A visible spectrum image of the full painting with the location of interest marked can be seen in Figure 1. The two infrared cameras used, a FAST M350 Mid-wave IR (MWIR, 1.5-5.4 µm) system, and a FAST L200 long wave IR (LWIR, 7.5-11.5 µm) system were both provided by Telops, while the flash lamps utilized were provided as part of a pulsed thermography PTvis system and the processing and control software by EDEVIS GmbH. The painting was inspected at 100Hz framerate by each camera and at various distances to achieve spatial resolution varying between 200µm and 900µm pixels.

To capture the PPT imagery a brief thermal pulse is emitted (3ms) which heats the surface of the painting. The thermal response of the painting is then captured by the infrared cameras. As the energy diffuses, the evolving time-profiles of particular localities can be assessed to thereby indicate the presence of notable features. Particularly for PPT, post processing of the imagery also includes converting the thermal information collected to frequency domain amplitude and phase information which can be retrieved after completing Fast Fourier Transforms (FFT) on time series sequences. When looking at the phase and amplitude information deeper layers can typically be viewed at lower frequencies while more shallow features are most visible at higher frequencies [1].

Figure 1: *A visible spectrum image of the full oil painting, with a red marker indicating the region of interest.*

3. Results:

Both MWIR and LWIR imagery have shown additional utility, uncovering new features previously unidentified beneath the painting's surface. Novel findings include irregular application of adhesive and varnish compounds, cracking and delamination of sub-surface interfaces, and an ability to view structural components on the underside of the painting through the painting surface. Additionally, while some features can be resolved in both sets of results, comparative analysis continues to show unique features independently present in either the MWIR or LWIR imagery. As one example, Figure 2 demonstrates the ability of the LWIR imagery to uncover details near to the surface, including varnish cracking and the previously noted pentimenti tower.

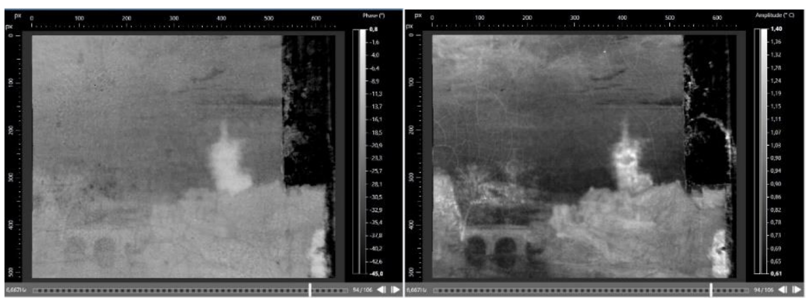

Figure 2: *LWIR Amplitude (Left) and Phase (Right) images of the region of interest at ν(Hz)* **=** *100Hz.*

4. Conclusion:

Continuous development of the active infrared thermography techniques described above has provided invaluable non-destructive tools to art historians aiming to better document and preserve cultural heritage artwork. Our research has shown that complementary use of both MWIR and LWIR pulsed phase thermography provides an ability for preservationists to better understand otherwise undetectable features within multi-layered panel paintings. These features, such as the artist's sketches and pentimenti, the presence and status of preparatory layers, and previous preservation efforts, provide otherwise unattainable insight, the use of which can improve conservatory methodology. Continued improvement and newly discovered capabilities suggest that wider adoption of this technology leading to additional research should be considered.

REFERENCES

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