

From Microwave to TeraHerz: electromagnetic imaging for cultural heritage

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Non-invasive inspections capable of imaging sub-surface features at different penetration depth and spatial resolution have a crucial role in the frame of cultural heritage, from archaeology to the analysis of artworks or their fragments. This motivates continuous research efforts finalized, on one hand, to improve the imaging capabilities of existing technologies and novel ones, and, on the other side, to design new inspection protocols exploiting different sensing techniques in a cooperative way.

Aim of this communication is to provide a brief overview of the recent advancements reached at IREA-CNR, where one of the faced challenges is the development of imaging methodologies able to conjugate the potentialities offered by innovative hardware solutions and advanced model based data processing tools. Specific attention is focused on Ground Penetrating Radar (GPR) that, as well known, is a radar instrumentation designed for localizing buried/embedded targets and to TeraHertz (THz) imaging, which is a new frontier of sensing methodologies.

Regarding GPR, one of the main issues is the raw data interpretability and Microwave Tomography is adopted as a flexible tool able to manage 2D and 3D imaging in several reference scenarios under different measurement configurations, including multi-antenna systems and radar mounted on Unmanned Aerial Vehicles (UAV) [1]. Moreover, cooperative use of GPR and other geophysical techniques is accounted for.

Regarding THz imaging, it allows a sub-millimeter cross-sectional representation, hence it is useful to analyze texture and stratigraphy of materials as well as to detect hidden defects or anomalies without implying long term risks for exposed objects and humans. However, the effectiveness of THz imaging is dependent on the data processing approaches and filtering procedures need to reduce the environmental noise and enhance the useful signal portion, i.e. the THz response of the targets. In this frame, a THz data processing chain has been proposed in [2] and applied to analysis several artworks.

Examples of GPR and THz results are depicted in Figure 1 and they will be discussed at the conference.



Figure 1. Examples of GPR and THz results.

References

- [1] I. Catapano, G. Gennarelli, G. Ludeno and F. Soldovieri, "Applying Ground-Penetrating Radar and Microwave Tomography Data Processing in Cultural Heritage: State of the Art and Future Trends," in *IEEE Signal Processing Magazine*, vol. 36, no. 4, pp. 53-61, July 2019, doi: 10.1109/MSP.2019.2895121.
- [2] I. Catapano, F. Soldovieri, A Data Processing Chain for Terahertz Imaging and Its Use in Artwork Diagnostics. *J Infrared Milli Terahz Waves* 38, 518–530 (2017). <https://doi.org/10.1007/s10762-016-0340-3>.