Terahertz time of flight imaging of hidden layers in *oleo* paintings

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***Abstract*—In this work we use the echoes of THz radiation pulses reflected from multilayer systems in order to find hidden layers in an oleo on canvas painting. We fit the reflected waveforms to a superposition of various echoes using a least square algorithm in order to separate overlapping pulses owing to reflections in sub wavelength layers.**

I. Introduction and Background

FOR art historians the possibility to study drawings or paintings below the surface layer is of vital importance, as this gives them information about the chronology of the artwork but more importantly, the state of preservation of the piece. Currently the techniques used to determine the state of conservation requires cutting a paint sample [1]. Recently with the improvement of THz-TDS system many researchers have proposed the use of this radiation to find layers hidden below the surface of the painting [2]. Many of the pigments used in paintings on canvas are transparent to this radiation making this technique an attractive candidate for the replacement of conventional techniques.

A. Preparation of multilayer painting on canvas

The multilayer system was prepared as show in Fig.1 First we deposited a white base coat on the canvas a), subsecuently a red oxide circle b), then the image was completely covered with a layer of cobalt blue c). Finally, a chrome yellow square was painted d).

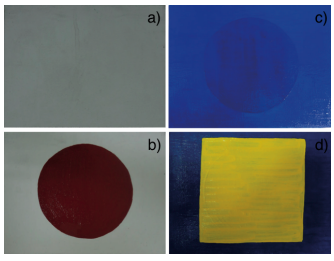

Fig. 1. Multilayer system using in the THz-TDS reflective system.

B. Least-square algorithm

In order to find the hidden layers we use a THz-TDS system in reflection configuration. We record the reflected pulses from the multilayer system. Then a reference pulse was measured by placing a mirror at the painting position. Using a least squares algorithm we adjusted the superposition of $n+1$ pulses with the same waveform as the reference to the reflected pulses of n layers system.

II. Results

In order to produce a three-dimensional image of the layers, we scanned the surface of the painting on a two-dimensional mesh using motorized stages, recording a separate waveform for each point. Each waveform was fitted to a a superposition of $n+1$ waveforms as described in the previous section. The resulting delay parameters for the echoes are used to produce the graphic shown in Fig.2. The separation between layers was increased arbitrarily for visualization purposes.

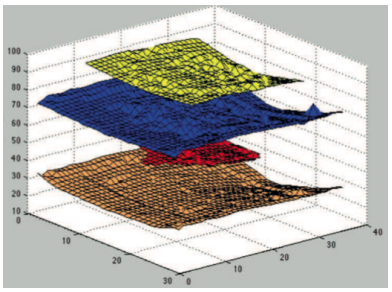

Fig. 2. Computational reconstruction of the multilayer system.

III. Conclusion

In this work we use reflection TDS and a least-square algorithm in order to reconstruct hidden oleo layers in a painting. This technique can be very useful in the historic study of real artwork as well as an evaluation tool for their conservation.

Acknowledgment

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References

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