Frequency modulated continuous wave terahertz imaging for art restoration

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***Abstract*— Art and heritage analysis techniques are important in the framework of restoration and conservation. Usual techniques for painting analysis are X-ray imaging and infrared raking light. We propose in this paper to present a case study of a painting analyzed by conventional methods and by terahertz imaging.**

I. INTRODUCTION

Analysis of hidden part on a painting is a key point for art historians, conservators, art restorer and conservation scientists. Particularly, art restoration is a growing field which concerns both important paintings present in museums and painting in private collections. The art restorer needs to know which kinds of defects are present on the canvas to apply the appropriate treatment methods. The most common defects are separations from old relining, crunches and cracks in the canvas. So far, frequently used techniques include imaging analysis with X-ray and infrared imaging.

Terahertz imaging is a method that has shown its relevance for analysis of hidden part of a painting [1]. THz pulse imaging has show its capability to provide information on the thickness of hidden paint layers and to observe the paintings stratigraphy [2]. These methods are associated to processing techniques [3] allowing to reconstruct the internal structure of objects in the framework of several non destructive applications like composite material inspection.

Most of these studies used pulse systems which provide the advantage of allowing a fine analysis and reconstruct different layers with an accuracy in the longitudinal axis of a few tens of microns. However, the speed of acquisition of these systems limits the use for small areas and for remarkable paintings in the context of collaboration with museums. The increasing frequency of electronic systems and recent developments in radar technologies allows today to consider the design of imaging systems in the terahertz domain with high acquisition rates.

We propose to use an imaging system based on frequency modulated continuous waves (FMCW) to analyze a painting before the restoration process. The system measure signal in both transmission and reflection in two frequency ranges, from 75 to 110 GHz and from 220 to 330 GHz.

II. RESULTS

The investigated painting has an oval shape with a size 50 x 80 cm. It is presumed dated of 18th Century. We can clearly observe some parts of the artwork (face , shoulder , hands) and the traces of ancient restoration. Image shown on Fig. 2 (c) was obtained with the 220-330 frequency range. It highlights clearly two main defects at the right and the left of the face and another one on the hand. 100 GHz range image shown on Fig. 2 (b) displays the same defects with a different contrast. Moreover, phase retrieval allowed by frequency modulation permits image reconstruction with several slice. This exhibits defects with varying contrasts depending on the position and permits separating reflection of the wood frame from canvas.

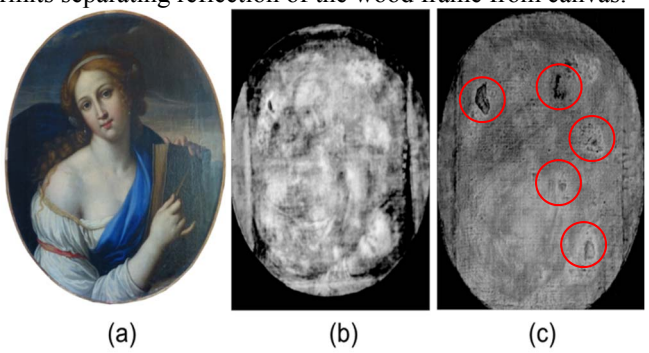

Fig. 2. (a). Photography of the investigated painting. (b) : THz image obtained in reflection in the 75-110 frequency range. (c) Image obtained the 220-330 frequency range. THz images highlights three defects around the head and on the hand. The mechanical stress caused by the vertical-frame is also visible.

III CONCLUSION

We demonstrate successfully that FMCW can be used for art painting analysis in the context of restoration. Results at 100 GHz and 300 GHz exhibits different defects. We believe that FMCW THz imaging is an alternate and complementary technique to the TDS systems and X ray imaging that could be useful for art restorers.

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