Investigation of Decay Mechanisms in Historical Artwork via TV Holography

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Abstract. The preservation of works of art calls for the investigation of underlying corrosive processes. TV-holography has proved to be a powerful tool for this purpose. A review will be given of various applications in diagnostics of works of art.

1 Introduction

The deterioration of historical valuable works of art is of major concern, as these objects represent part of our cultural heritage. Their preservation is thus a priority task in order to maintain these tokens for the next generations of mankind.

The causes of deterioration are consequences of century-long climatic impacts aggravated by man-made pollution of recent years. Effective preservation calls for the investigation of underlying corrosive processes, which are not yet fully understood [1]. To take care of the delicate objects and for an early diagnostic warning, non-destructive and highly sensitive techniques are most favourable. Thus, optical inspection with interferometric sensitivity is extremely well suited for this task. However, investigations under adverse conditions outside the laboratory at a monument site must meet special requirements. In the last couple of years, TV-holography or electronic speckle pattern interferometry (ESPI) has proved to be the favourite candidate for this purpose.

Introduced by Butters and Leendertz in the early 1970s [2], TV-holography is basically a holographic method. Instead of using photographic films, the recording of the interference patterns is performed by a video camera, avoiding the troublesome chemical developing process. It has been known for a few years that diagnostics and conservation of works of art can greatly benefit from TV-holography, too. However, the method is far removed from a widespread utilization in the field of conservation. Consequently, there are only few research groups using TV-holography intensively for preservation purposes. The method offers almost the same variety in different modifications as conventional holography. Depending on the specific realization of the experimental setup, the
method reveals a variety of useful information about the historical artefacts under investigation. This paper reviews the state of the art in the application of TV-holography to diagnostics of works of art.

2 Deformation Mapping

One of the most important applications of TV-holography is the study of minute surface displacements that are connected with omnipresent physical and chemical impacts. The monitoring of tiny deformations due to e.g. climatic changes or corrosion can help to obtain insight into decay processes, identify object areas of special concern, yield material properties or serve to control the success of conservational remedies.

![Diagram of a typical TV-holography setup for monitoring static deformations.](image)

In Fig. 1 the schematic setup of a typical TV-holography system is presented that is able to measure static deformations on a micrometer scale. Since the method is comprehensively described in literature, e.g. in [3], only the principle of operation is outlined here. The light of a laser illuminates the surface of the object under investigation. Meanwhile, small and compact diode lasers in the near infrared wavelength region are utilized, in many cases with output powers in the order of 100 mW. This is sufficient to illuminate areas up to about a quarter of a square meter. Due to the coherence of the laser light, a speckled image of the surface is formed on the target of a video camera, typically a small and handy CCD camera. The field of view can be adjusted by a zoom lens or exchangeable optics. To obtain interferometric sensitivity, a part of the illuminating wave is divided by a beamsplitter and superimposed on the objects image. Hence, an image plane hologram is created on the target of the CCD-camera.

Instead of storing the superimposed light fields on photographic media as in traditional holography, the interference patterns are captured electronically. The holographic information can be digitized and processed with a PC-based image