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The Scream (ca. 1910) through the Years: from Photographic Documentation to Spatio-Temporal Modelling

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Abstract

The Scream (ca. 1910) is one of Edvard Munch's representations of the well-known scene of a man awestruck by the beauty and colors of the sunset over the fjord, painted in oil and tempera on cardboard. Given the age of the artwork, it is expected that its appearance has significantly changed since its creation to the current state. Previous studies found that the yellow and dark red hues that depict the sky are especially sensitive to moisture and light exposure, respectively. In addition, several film photographs were taken of the painting between 1970 and 2003. In this work, we aim to use these photographs in an attempt to model the changes that the artwork withstood, and reconstruct its past appearance. We perform color correction of the photographs, by comparing the unfaded values in the films against reference values in the current version of the painting. To define the reference values, we use the existing knowledge on the highly sensitive areas and other damages that occured to the painting. Finally, we obtain a color transformation function that facilitates the digital rejuvenation of the painting appearance.

CCS Concepts

• ***Applied computing*** → ***Fine arts;*** • ***Computing methodologies*** → ***Model development and analysis;***

1. Introduction

Digital rejuvenation [BBC*06] estimates the past appearance of a painting, and is of high interest for art historians, conservators, museum curators, educators and the general public. In the last decade, several approaches were proposed in this sense, where scientific data collected from an artwork (such as spectral reflectance, elemental maps, fading behaviour) are coupled with analytical [ZvdLL19, CPGH23] and physically-based models [KLL*18] and/or artistic editing in image processing software [FKHS17, Ber19, BZM*22].

In some fortunate cases, information with respect to a painting's composition and previous appearance can be retrieved from documentary sources and archival records, where a good example is given by Vincent van Gogh's letters describing his artistic process to his brother [vG]. Similarly, photographs from the past can represent a useful piece of information to monitor the change of an artwork [SKR*16]. However, photographic documentation presents an important challenge, that of accurate color calibration. This is especially problematic for film photographs, that are themselves subject to degradation due to dye decay, and are generated with complex photo-chemical processes.For instance, in an attempt to restore the film photographs of Brazilian artist Candido Portinari, Leão [Lea11] found a lower stability for the colour patches of the Kodak Q-13 control target with respect to the grayscale patches.

In this work, we intend to develop a novel color correction method for the film photographs of *The Scream* (ca. 1910) in Munch Museum's collection that provides the artwork's accurate colors at the time in which the image was taken. Our approach is to obtain the color transformation relying on ground-truth scientific data that characterizes the materials in the painting and their aging behaviour. This is somewhat similar to the idea of Stenger et al. [SKR*16] who use the unfaded parts of Rothko's Harvard murals in the creation of the digital reconstruction. However, different from [SKR*16], we include the map of unfaded regions in the film color correction stage. The ultimate purpose of our proposed method is to employ the existing photographic documentation towards the digital rejuvenation of *The Scream* (ca. 1910).

As a support to our work stands an extensive prior investigation of *The Scream* [SATCT10, CSR*19, MCR*20, CAC*22, CAŁ*22], that characterized the materials in the painting and their corresponding degradation behaviour in relation to aging factors such as moisture and light. In particular, Monico et al. [MCR*20] found that the yellow brushstrokes in the sky shades and main's character figure (throat) faded due to the chemical reaction of the cadmium sulfide pigment with humidity. In addition Chan et al. [CAŁ*22] used microfadeometric measurements to investigate the lightfastness of different colored areas of the painting and discovered that the red colors in the sky, painted with vermilion, are the most sensitive to light exposure. So far, these findings have been useful to formulate the exhibition policy and most suitable environmental con-

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ditions for the painting's public display. Now, the focus is brought to the digital color reconstruction of the painting's appearance.

2. Materials and Method

The earliest analogue color picture of *The Scream*, on a large format Kodak film, dates from the 1971 and it is followed by two large format Agfa films shot in 1989, 1993, and lastly a 35 mm Fuji film shot in 2003. This represents a documentation of the painting along 4 decades. Fig. 1 shows the series of existing films. All the photographs include Kodak Q-14 Color Control Patches [kod]. These patches may be useful to develop the color correction. The oldest photograph (1971) has an overall red cast due to the fading of the cyan dye, thus it should to be treated with a digital unfading process such as the one described in [CTR23] before applying the color correction.

Figure 1: *The film photographs of The Scream in 1971, 1989, 1993, and 2003 (in order from left to right).*

The color correction becomes possible thanks to the extensive scientific investigation that has been carried out on the artwork. From the microfading data collection in [CAŁ*22], which outputs the color difference of a measured spot as a function of exposure to light (see plot in Fig. 2), we get a ranking of the fugitive areas. For instance, the red color in the sky region has the highest light-induced sensitivity. Similarly, from the study of [MCR*20] we know that the yellow hues in the sky and main character throat suffered degradation due to moisture. Then, from the Macro X-ray Fluorescence (MA-XRF) data [CSR*19, CAC*22], we can identify the chemical elements present in the faded regions. The corresponding pigments, namely vermilion and cadmium sulfide, were mapped and their distribution correlated on the whole surface of the painting. This map is complemented by another change that occurred during the 2-year period the painting went missing following its theft in 2004: the painting was visibly damaged by a water-based agent in the bottom-left corner. The inverse of this map isolates the areas that least changed, or to simplify, the intact parts of the painting, which establish a correspondence between the artwork and the film sheets. In addition, in 2017, the artwork was captured with hyperspectral imaging in the visible and near-infrared [SFM*18, CSR*19], so the current spectral and colorimetric values of the painting are available.

In order to capture the spectral densities of the slides, the four films are acquired with a hyperspectral camera, HySpex VNIR-1800 [Nor], that captures 186 bands in the 400 nm - 1000 nm range. A correspondence has to be found between the optical properties

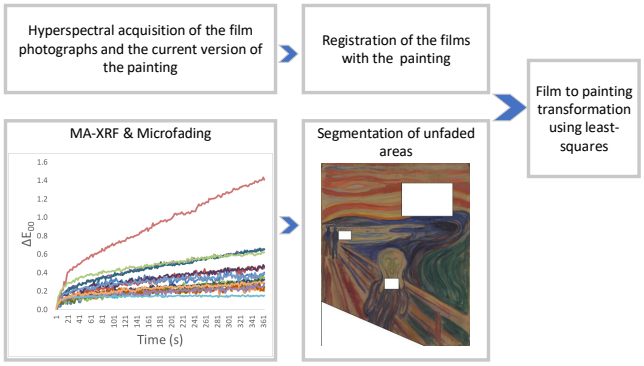

Figure 2: *Our method performs color correction of the film photographs based on the map of unfaded areas in the painting. Unfaded areas are assumed to be constant between the current version of the painting and the 4 films.*

of the artwork and those of its photographic image. The correspondence will be determined based on the unfaded parts of the painting. In addition, useful anchor points for the color correction can be offered by the Kodak Control Patches in the films.

For the development of the color transformation, consisting of a set of look-up tables and correction matrices that undo the color alteration of the photographic process, the dataset of Kreyenbuehl [Kre15] who captured the X-Rite Color Checker Digital SG on a variety of film stocks will be of great use. So will be the colorimetric measurements of Kodak Q-13 control targets from three different manufacturing years (1977, 2000, and 2007), performed by Leão [Lea11].

Finally, through a correct color correction of the 4 photographs and by accounting for the film processing and degradation mechanisms, we can achieve an aging reversal of *The Scream* from its current version to the last four decades. For now, our film to painting transformation function is discrete, and recovered for the 4 dates when the film slides were shot, but in the future we plan to apply interpolation to obtain a continuous curve.

3. Discussion

This article presents a work in progress that is part of the newly started project, Perceptive Enhanced Realities of Colored Collections through AI and Virtual Experiences (PERCEIVE). One of the aims of this project is to virtually bring faded artworks closer to their original appearance with the use of machine learning algorithms. The idea we propose here fits the scope of the project and puts together multiple sources of data in an interdisciplinary working context.

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