

FILM2PAINT: Transforming photographic documentation on reversal film into paintings' accurate colors

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Is it possible to use analogue photographic documentation to determine the appearance of an artwork in the past?



**ICC Spectral Imaging
Experts' Day**

Context

**"NOTHING IS PERMANENT
EXCEPT CHANGE."**

Heraclitus

**Ancient Greek
Philosopher**

(c.535 BCE - c.475 BCE)



Historic Photographic Documentation

Junger Proletarier (1919), by
Paul Klee, Zentrum Paul Klee



Kodak Ektachrome film (1995)



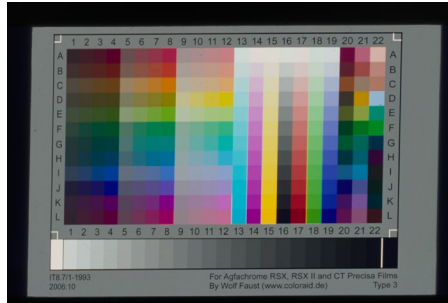
Digital image (2005)

- Film documentation of paintings was widespread from the 1960s until the digital revolution
- Different film stocks have different chromogenic processes

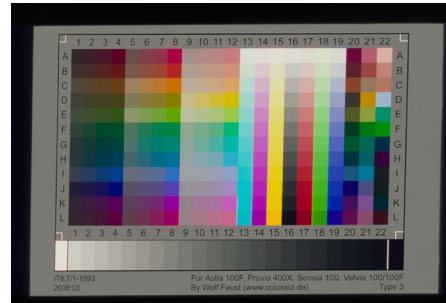
Ciortan, I. M., & Trumpy, G. (2024, April). FILM2PAINT: Transforming Photographic Documentation on Reversal Film into Paintings' Accurate Colors. In Archiving Conference (Vol. 21, No. 1, pp. 17-22). IS&T 7003 Kilworth Lane, Springfield, VA 22151 USA: Society for Imaging Science and Technology.

Historic Photographic Documentation

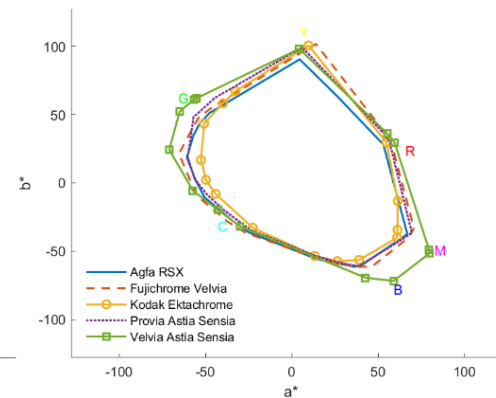
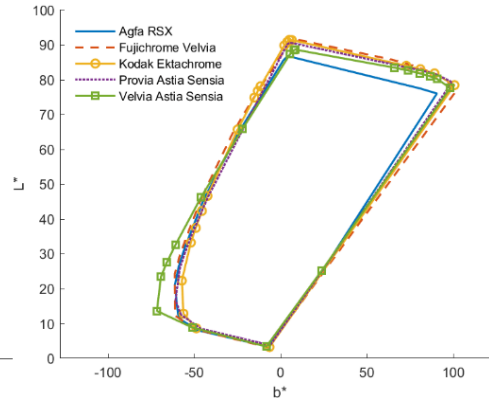
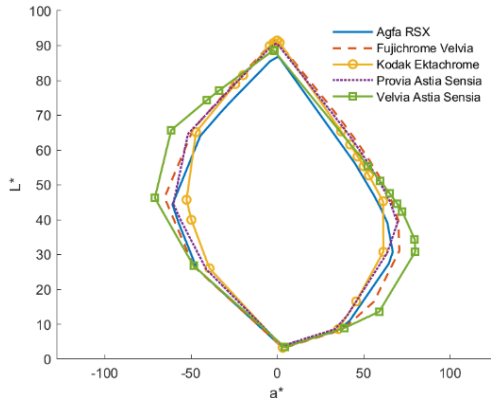
Coloraid It-8 on AgfaRSX



Coloraid It-8 on Velvia, Astia, Sensia



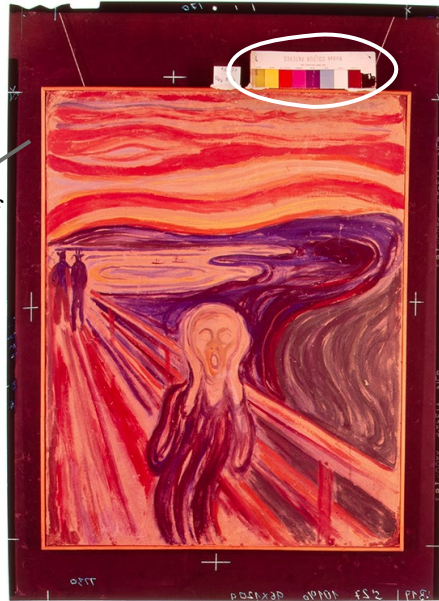
- Different films, (slightly) different colours



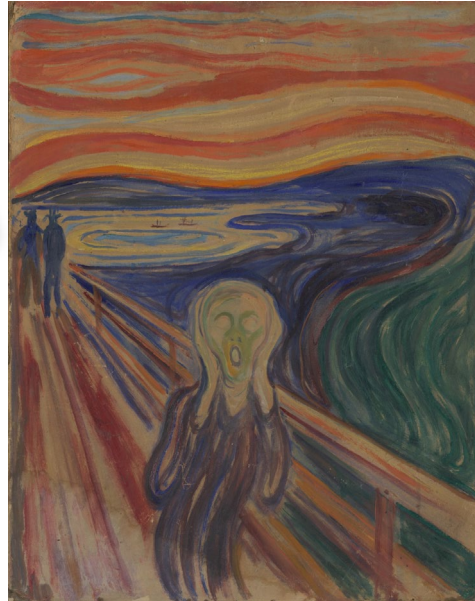
Ciortan, I. M., & Trumpy, G. (2024, April). FILM2PAINT: Transforming Photographic Documentation on Reversal Film into Paintings' Accurate Colors. In Archiving Conference (Vol. 21, No. 1, pp. 17-22). IS&T 7003 Kilworth Lane, Springfield, VA 22151 USA: Society for Imaging Science and Technology.

Historic Photographic Documentation

The Scream (cca. 1910) by Edward Munch, Munch museum



Kodak Ektachrome (1971)



Digital Image (2017)

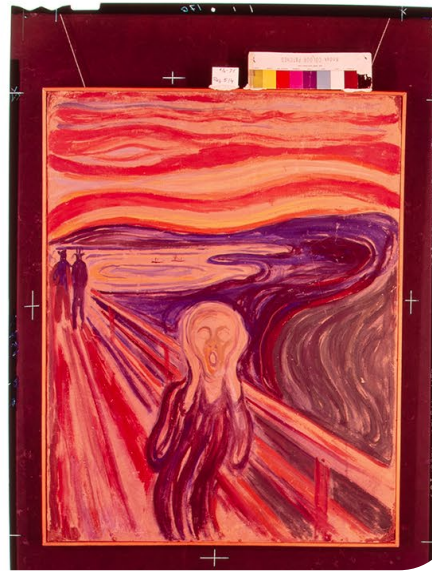
- Prior to the 1980s, dyes were more fugitive
- And colour control patches were not yet standardized
- Thus, not reliable enough for performing color correction (Leao A.)

Leao, A. C. (2011). *Restauração cromática digital de fotografias em filme a partir da cartela Kodak Q-13: Estudo de caso do acervo do Projeto Portinari.*

How to design the Film2Paint transformation?



Case 1: relying on the colour control patches in the film



Case 2: relying on conservation studies that show what changed

Case 1: Colour Control Patches

Junger Proletarier (1919), by Paul Klee, Zentrum Paul Klee

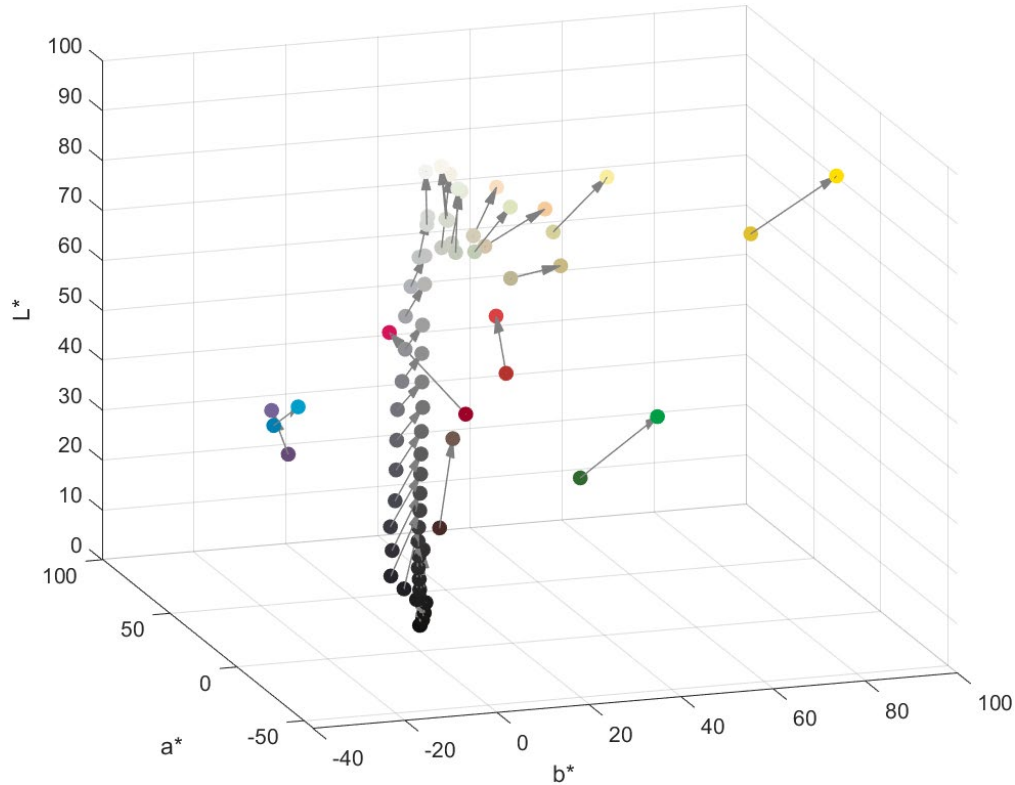


Kodak Ektachrome film (1995)

- Reference spectral measurements (from 1989) by Robin Myers



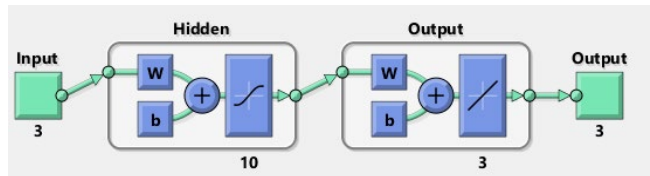
Kodak Color Control Patches, spectral measurements
https://www.chromaxion.com/information/kodak_color_control.html



- Arrows from the film colours to the reference measured colours, for the Kodak control patches

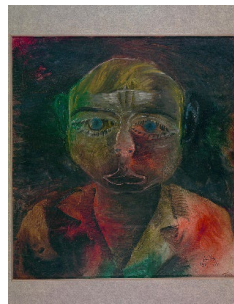
Transformation models

- Baseline: look-up table and first-order polynomial (3x3 matrix)
- Poly2D: Second-order polynomial
- Poly3D: Third-order polynomial
- NN: Shallow feed forward neural network



Colour corrected film

Digital scan of the painting (2005)



Average color difference

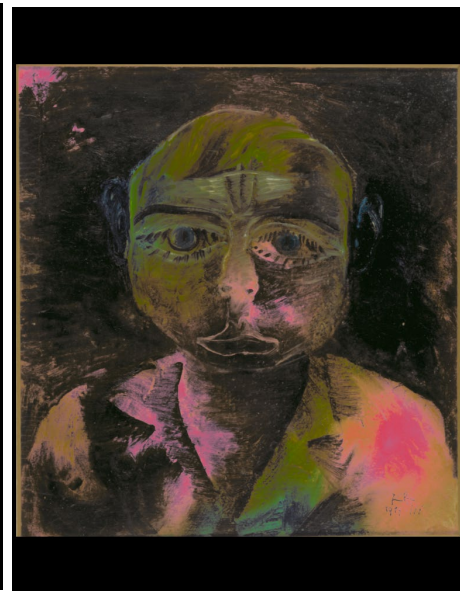
Not corrected Test Klee	14.08
Baseline Train	4.91
Baseline Test Klee	12.5
NN Train	0.80
NN Test Klee	11.17
POLY2D Train	3.34
POLY2D Test Klee	13.36
POLY3D-Train	2.69
POLY3D- Test Klee	11.93

Baseline

Poly2D

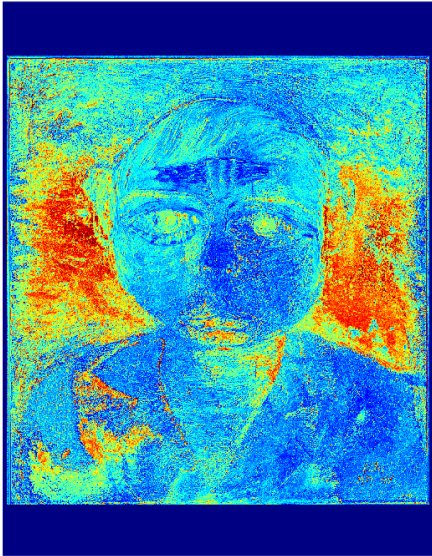
Poly3D

NN

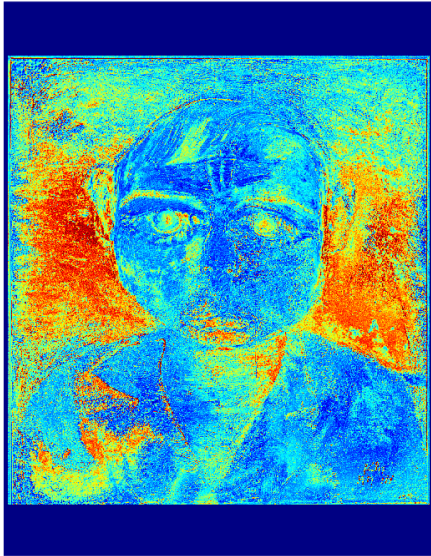


Colour differences wrt digital scan of the painting

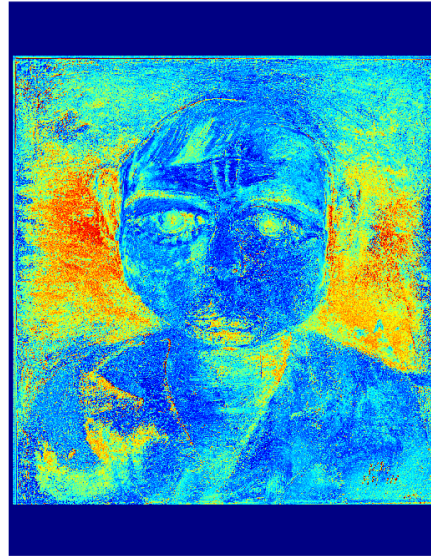
DE00 Baseline



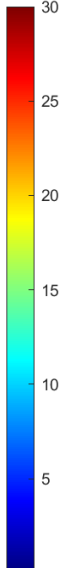
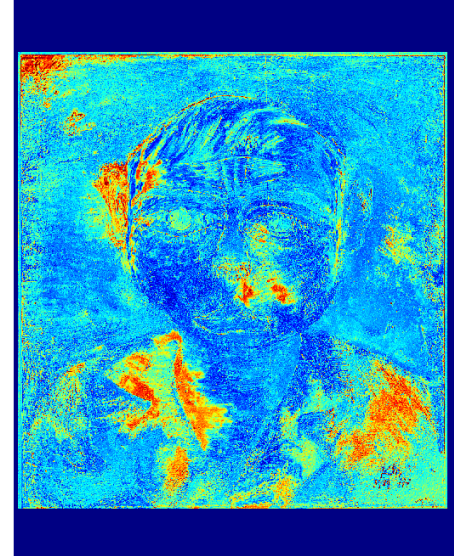
DE00 POLY2D



DE00 POLY3D



DE00 NN ColorGray



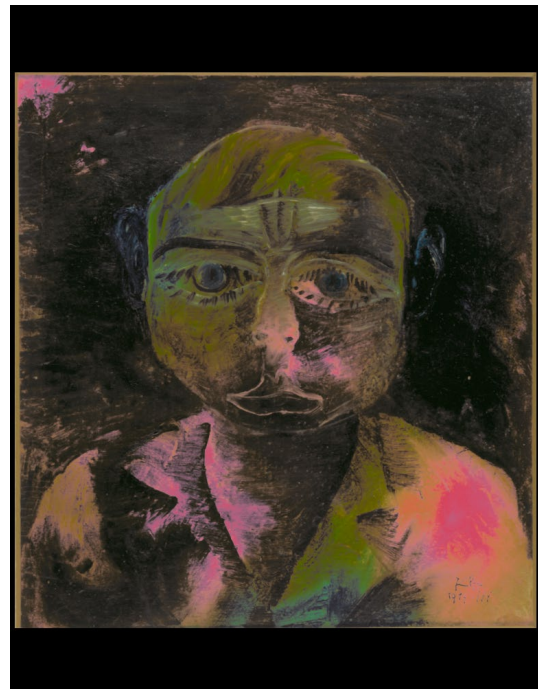
Possible conservation treatment before the digital scan?



Kodak Ektachrome film (1995)



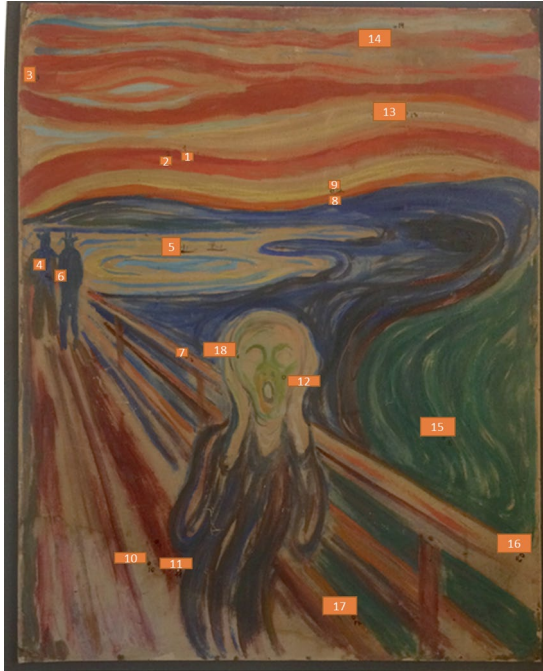
Digital image (2005)



NN corrected film

Case 2: transformation informed by conservation studies

The painting The Scream (ca. 1910) by Edvard Munch, Munch museum



- Conservation scientists detected color changes in areas that correspond to certain pigments (vermilion and cadmium yellow)
- Then with elemental analysis (Macro X-Ray fluorescence), the corresponding pigments were identified and mapped
- Resulting in a map of points in the painting that have changed

Cartechini, L., Sandu, I. C. A., Rosi, F., Grazia, C., Monico, L., Romani, A., De Freitas, R. P., Godzimirska, M., Chan, E., & Landro, G. (2019). The “Scream” by Edvard Munch (1910): Non-invasive integrated spectroscopic investigations of the painting materials. *Ma-XRF Conference*, 1(2).

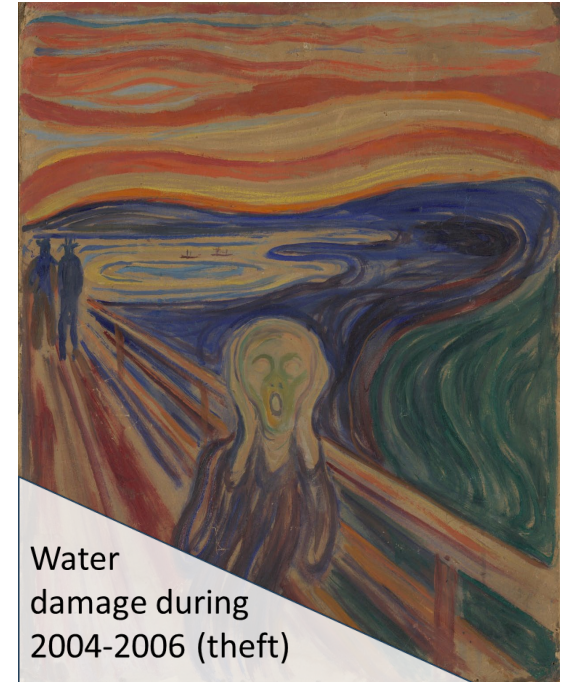
Map of changes



Vermilion



Cadmium Yellow



Water
damage during
2004-2006 (theft)

Map of changed areas in the painting

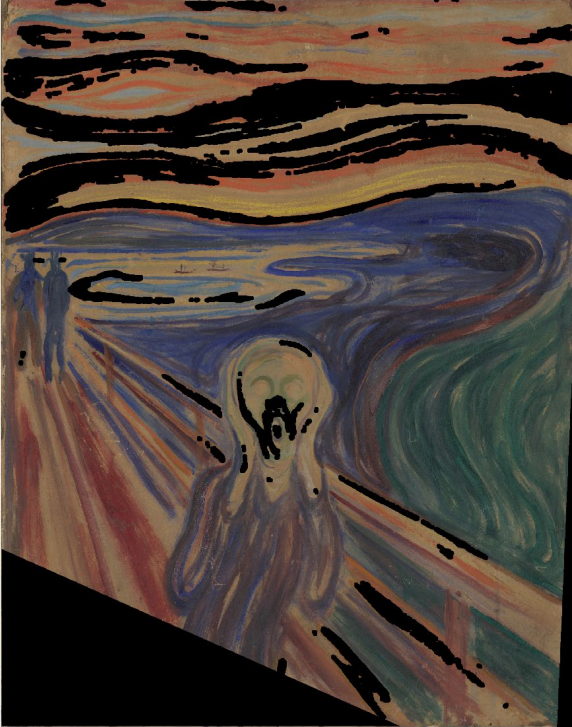


Use the painting as reference

- Changes occurred in:
 - Areas that overlap with **sensitive pigments**
 - And bottom left corner
- The rest changed very little

Ciortan, I., Trumpy, G., Sandu, I., & Bjørngård, H. (2023). The Scream (ca. 1910) through the Years: from Photographic Documentation to Spatio-Temporal Modelling.

Stable areas in the painting become anchor points



Use the painting as reference

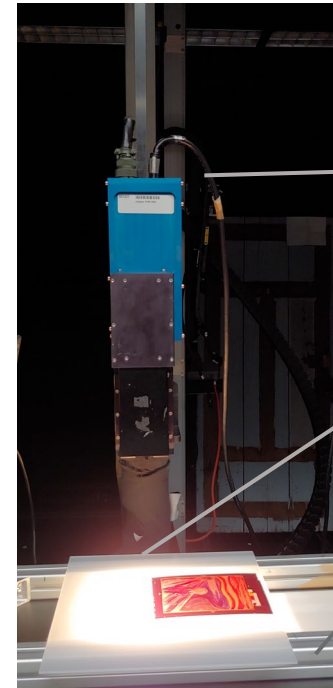
- Use the un-changed areas as reference anchor points...
- ...to compute a film-to-painting transformation...
- ...between the last digital scan of the painting in 2017 and the 1971 film

Ciortan, I., Trumpy, G., Sandu, I., & Bjørngård, H. (2023). The Scream (ca. 1910) through the Years: from Photographic Documentation to Spatio-Temporal Modelling.

Image capture

- The **film** was scanned with a **transmittance hyperspectral imaging** setup
- The **painting** was previously captured with a **reflectance hyperspectral imaging** setup (Cartechini et al.)
- Color images were obtained by integrating the reflectance signal for D65 standard illuminant and CIE 1931 standard observer
- The film and digital image were geometrically aligned and registered

Transmittance imaging setup



HySpex VNIR-1800 captures 186 spectral bands for every pixel.

The films were backlit by a halogen light source.

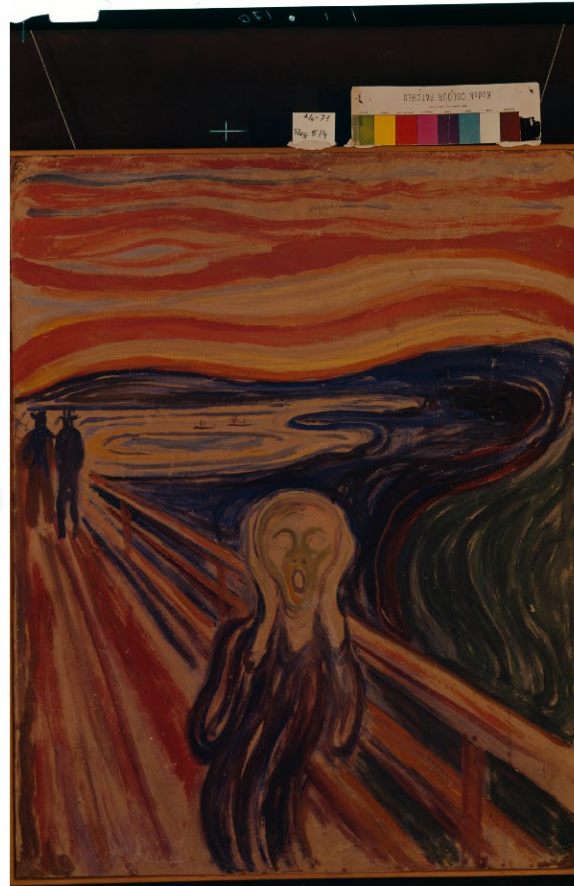
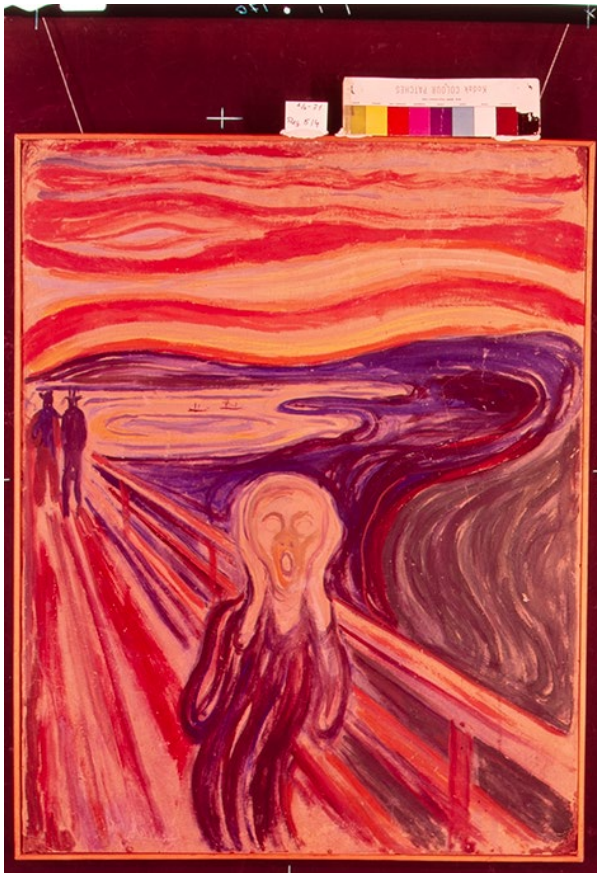
While moved by a translational stage.

Cartechini, L., Sandu, I. C. A., Rosi, F., Grazia, C., Monico, L., Romani, A., De Freitas, R. P., Godzimirska, M., Chan, E., & Landro, G. (2019). The “Scream” by Edvard Munch (1910): Non-invasive integrated spectroscopic investigations of the painting materials. Ma-XRF Conference, 1(2).

Pre-processing step

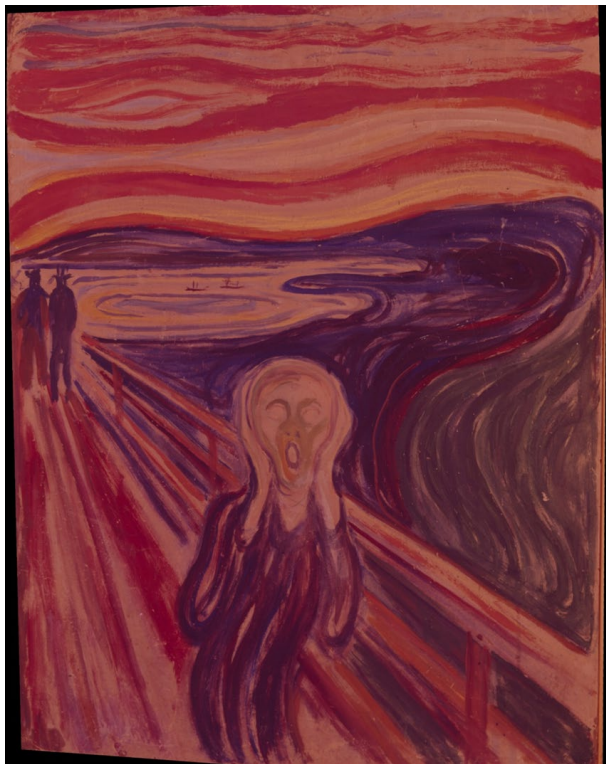
- Adjustment of the spectral densities of the dyes so that they match the original concentrations

Chatterjee, S., Trumpy, G., & Ruedel, U. (2023). Digital unfading of chromogenic film informed by its spectral densities. *Heritage*, 6(4), 3418-3428.



Film to painting transformation using NN

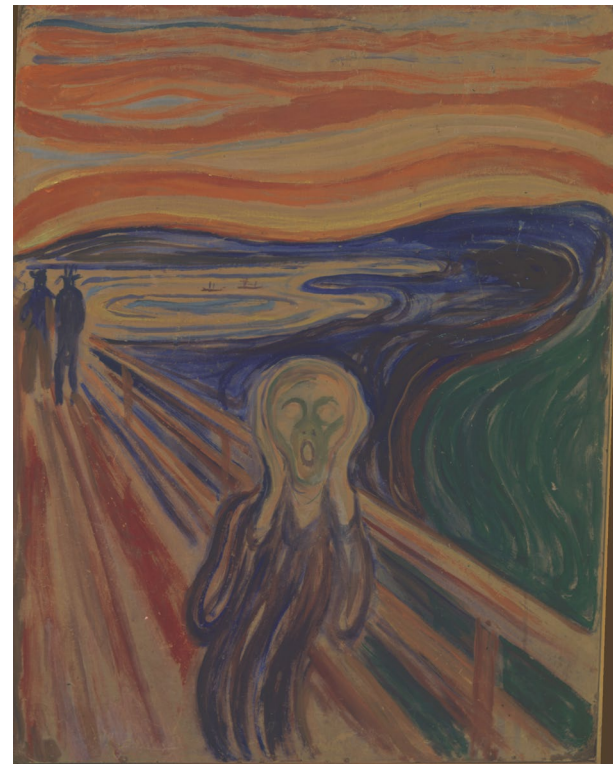
1971 film showing the loss of cyan dye



Painting 2017

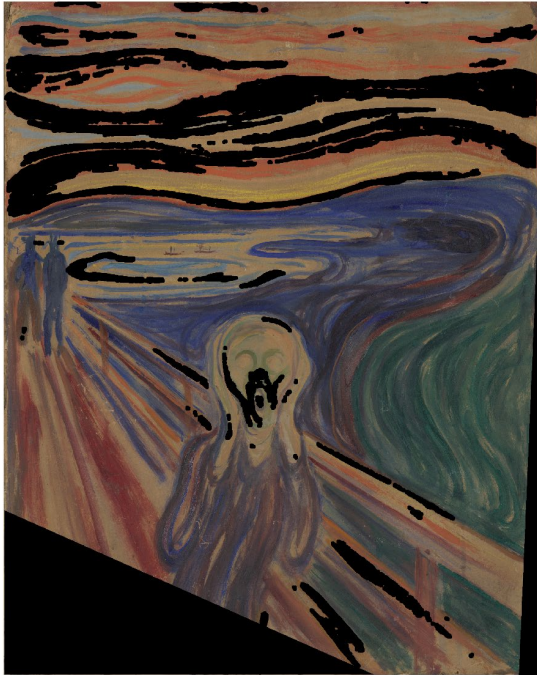


After the color transform, the film resembles more the painting

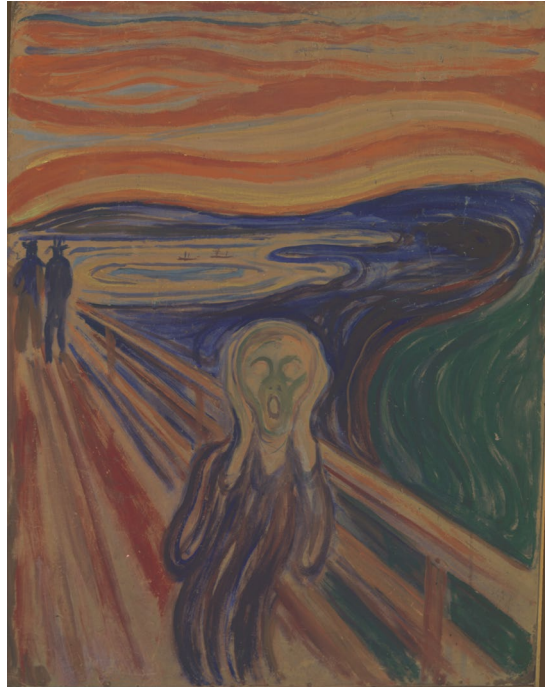


The corrected 1971 film

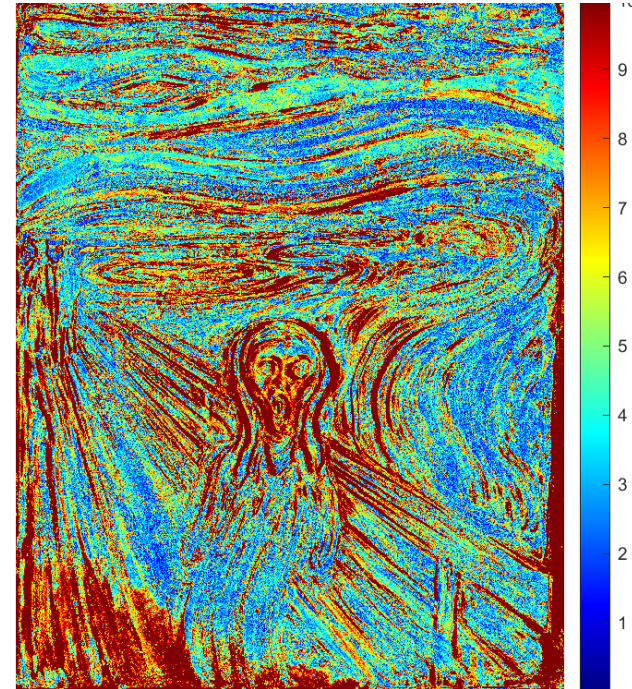
Stable areas in the painting



Film 1971 corrected



ΔE





Is it possible to use analogue photographic documentation to determine the appearance of an artwork in the past?

Conclusions

- Methods from traditional color management can be adopted to **improve the accuracy of analogue records of paintings**
- The **colour control patches** used in analogue photography are reliable as reference only to a certain extent
- **Material characterization** and aging analysis can provide the **reference** for color correction
- Potential **limitations** in overcoming difference in geometrical and optical setups (for example, focus) between the film and digital captures