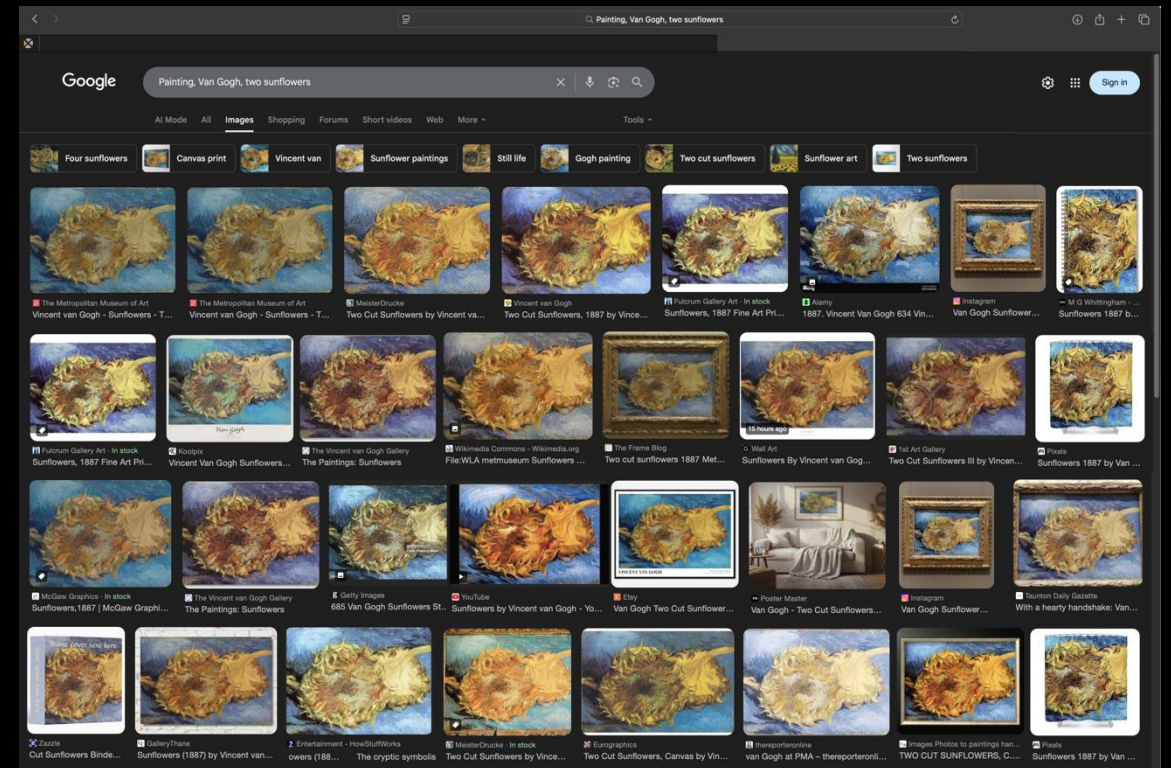


# On Color Fidelity

Applying Scene-Referred Color Reproduction Standards to 3D Artwork Reproduction



Scott Geffert, General Manager Imaging, the Metropolitan Museum of Art

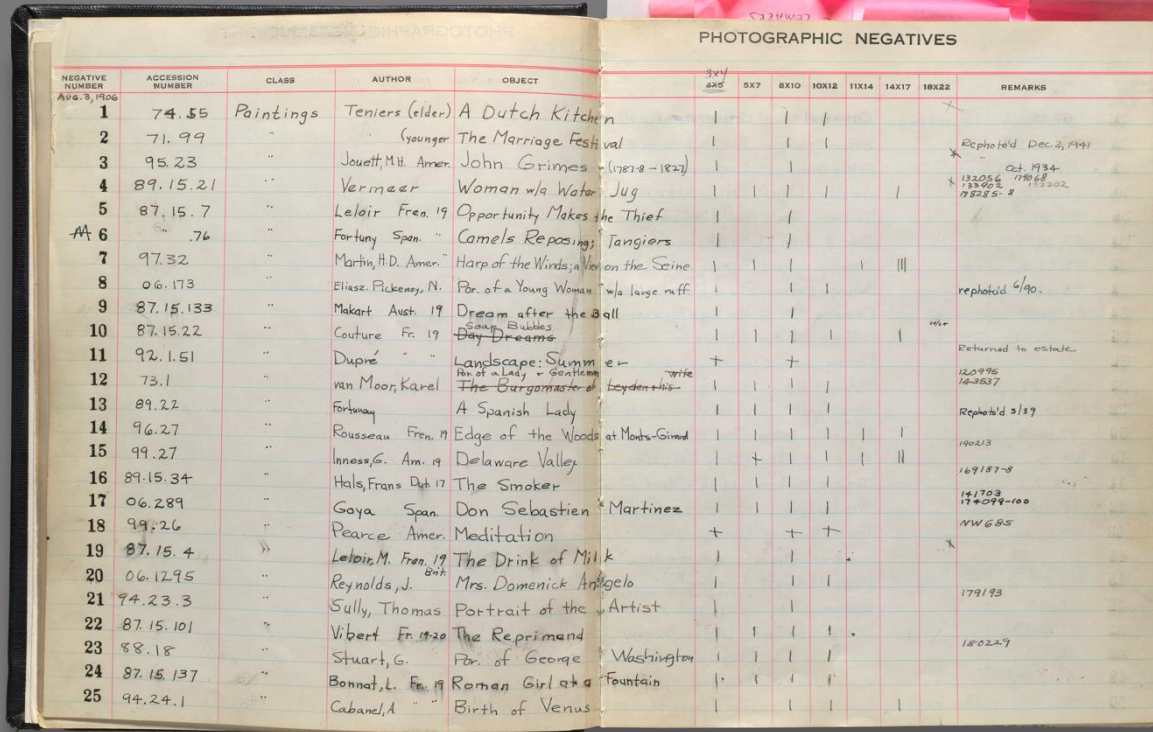
# Converging Imaging Standards



# Converging Imaging Standards



3D Imaging is a natural evolution of still Photography



# 1906-1995 Analog



# Van Gogh Sunflowers 1949



<https://www.metmuseum.org/art/collection/search/436524>

# Van Gogh Sunflowers 1983



# 1995 Early Digital



# 2000 Managing Color



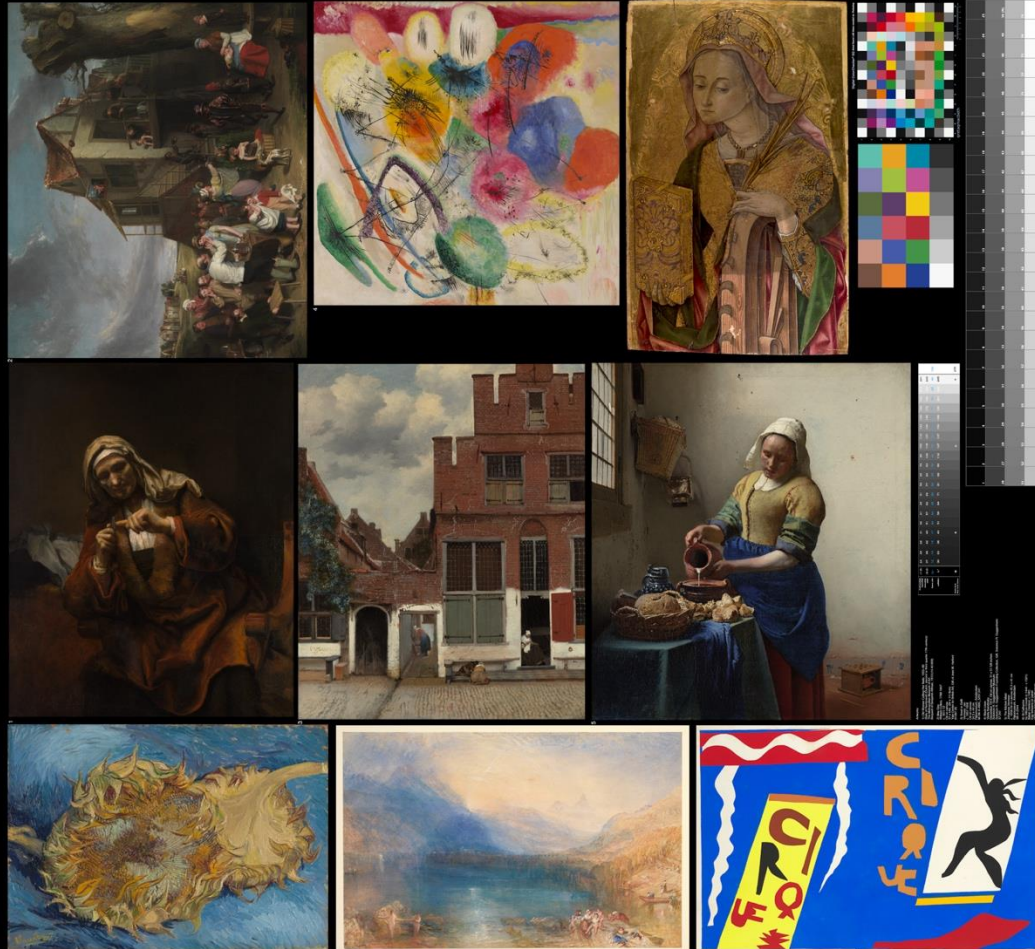
# International Collaboration



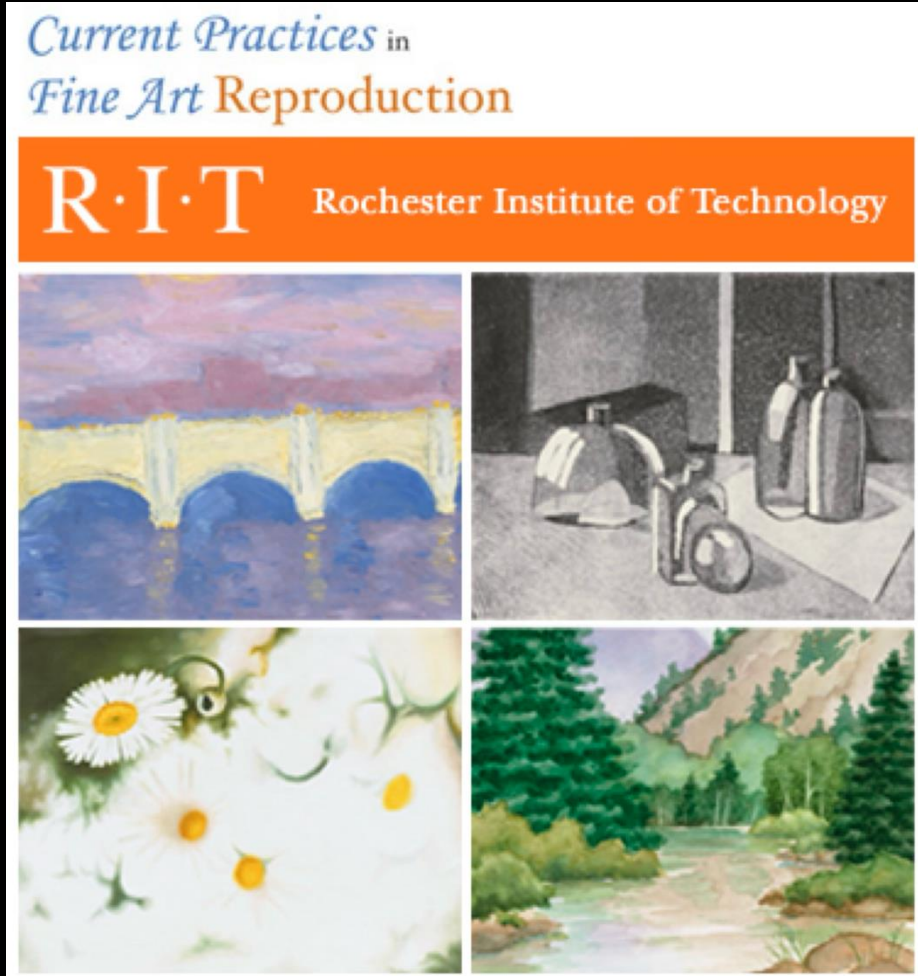
2004 International imaging conference, The PalaceOutput-Referred Subjective Editing Presented  
Museum-Beijing Challenges

# 2007 Standards Efforts

The Rijksmuseum  
The Metropolitan Museum of Art  
The Guggenheim Museum  
The V&A  
Yale Center for British Art  
The Referred Capture to ISO



# 2011 Final RIT Report



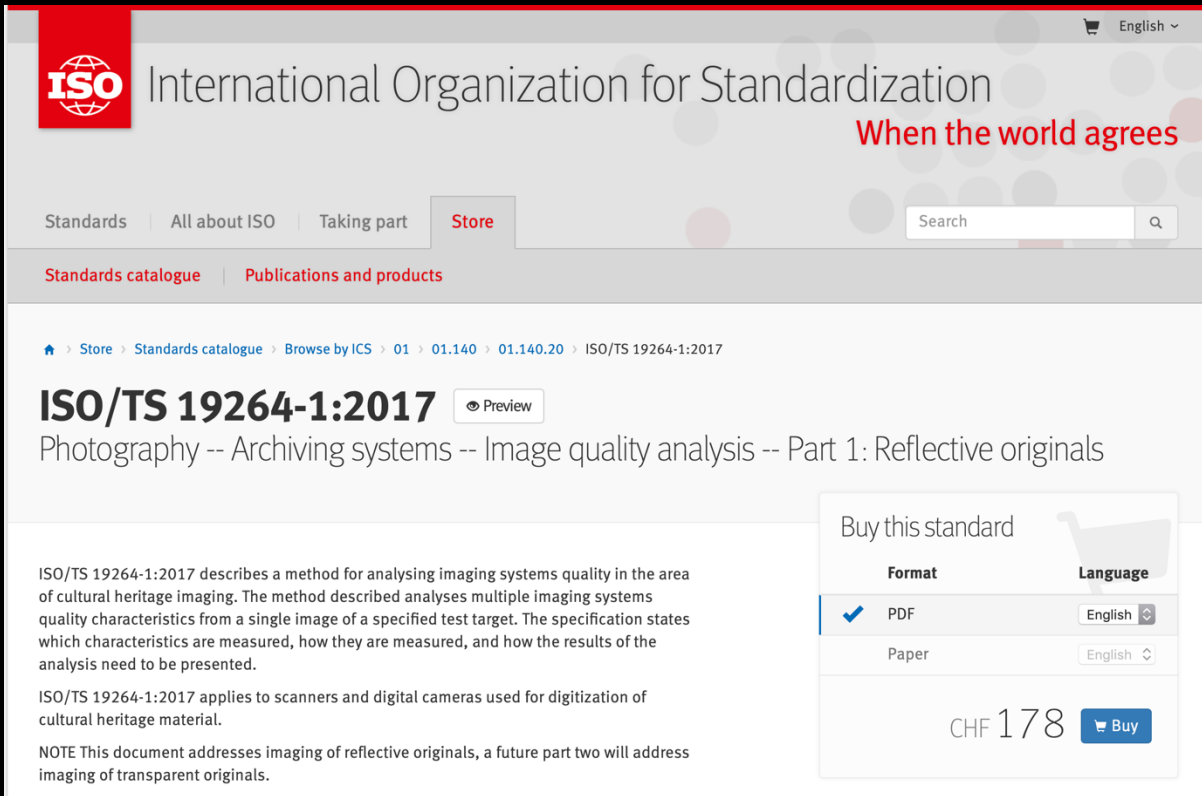
## Section 3: Experiments



Figure 3-5. Hard copy experiment process

The observers who participated in the experimentation for this project generally consisted of individuals in the cultural heritage community. The observers included librarians, photographers, curators, art teachers, conservators, and imaging science students and staff with an interest in fine art reproduction. Observers were tested for color vision anomalies with Ishihara plates. One observer in Experiment I had color vision test results that showed evidence of a significant red-green anomaly. His results were analyzed separately.

# 2017 ISO Standardization



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## ISO/TS 19264-1:2017

Photography -- Archiving systems -- Image quality analysis -- Part 1: Reflective originals

ISO/TS 19264-1:2017 describes a method for analysing imaging systems quality in the area of cultural heritage imaging. The method described analyses multiple imaging systems quality characteristics from a single image of a specified test target. The specification states which characteristics are measured, how they are measured, and how the results of the analysis need to be presented.

ISO/TS 19264-1:2017 applies to scanners and digital cameras used for digitization of cultural heritage material.

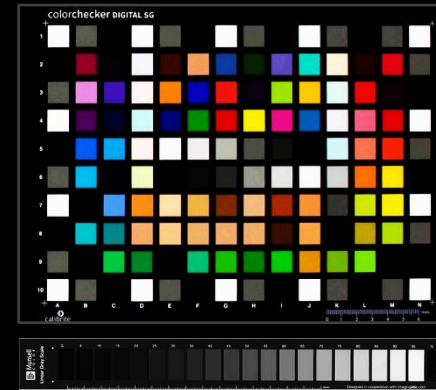
NOTE This document addresses imaging of reflective originals, a future part two will address imaging of transparent originals.

Buy this standard

Format: ☒ PDF ☐ Paper

Language: English

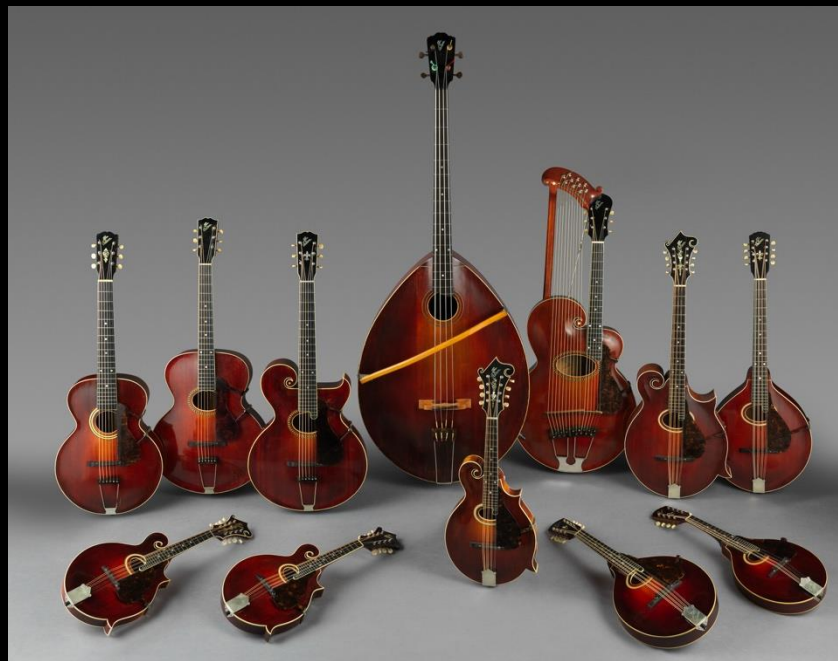
CHF 178

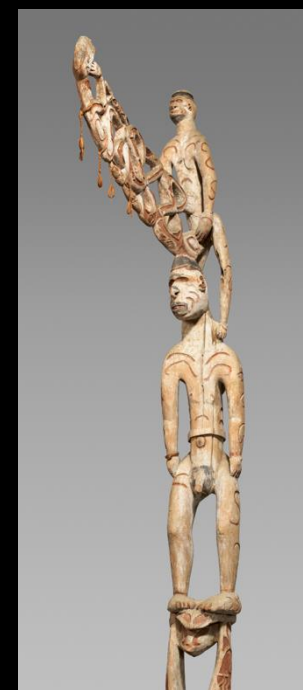


Fail



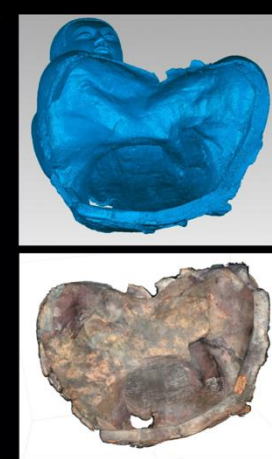
Pass







# 3D Imaging est. 2016

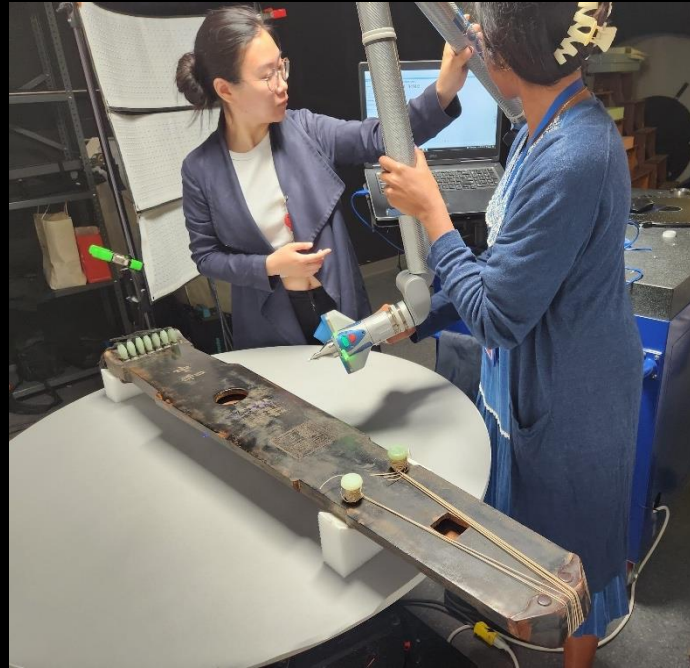


# 3D Imaging Techniques

## Photogrammetry



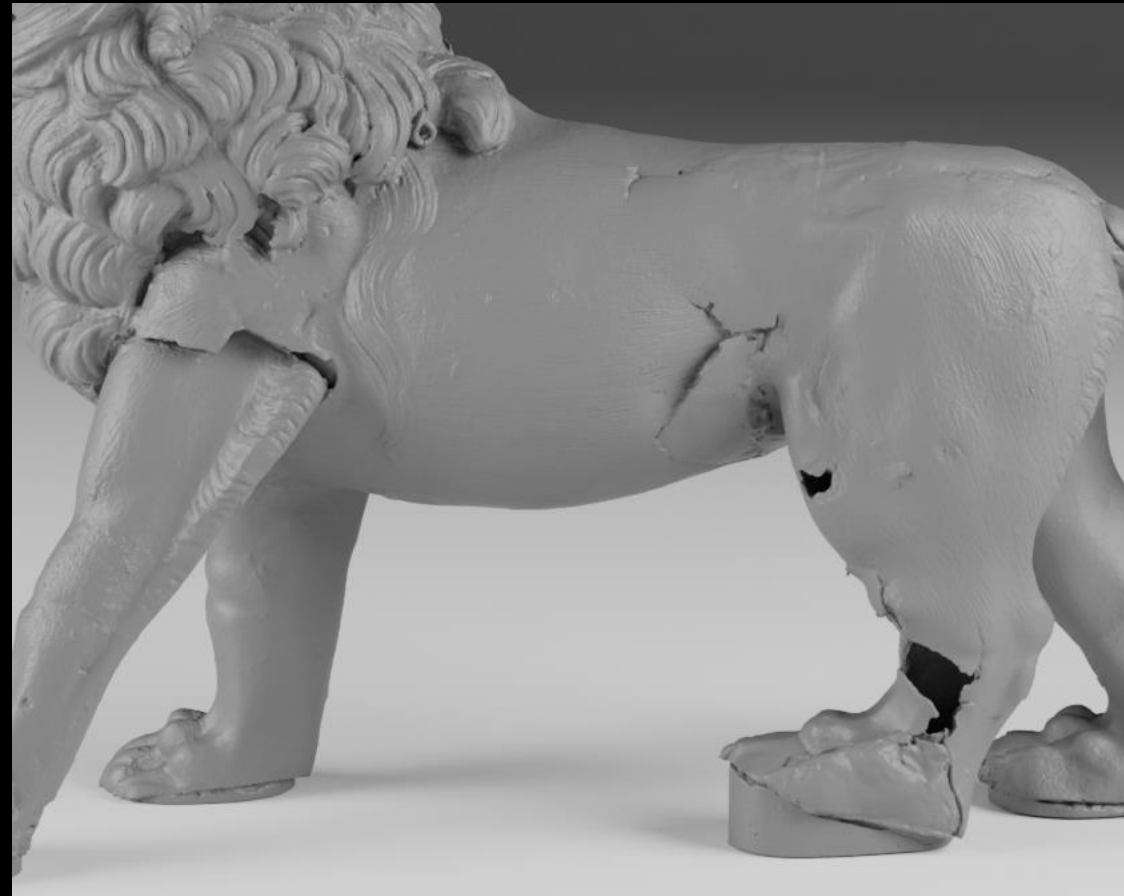
## Laser Scanning



## Structured Light



# 3D Imaging



Bronze statuettes of Lions from the Cybele Group (97.22.24) for Parco Archeologico del Colosseo

# 3D Imaging est. 2016



The Temple of Dendur Imaging, Behind the scenes

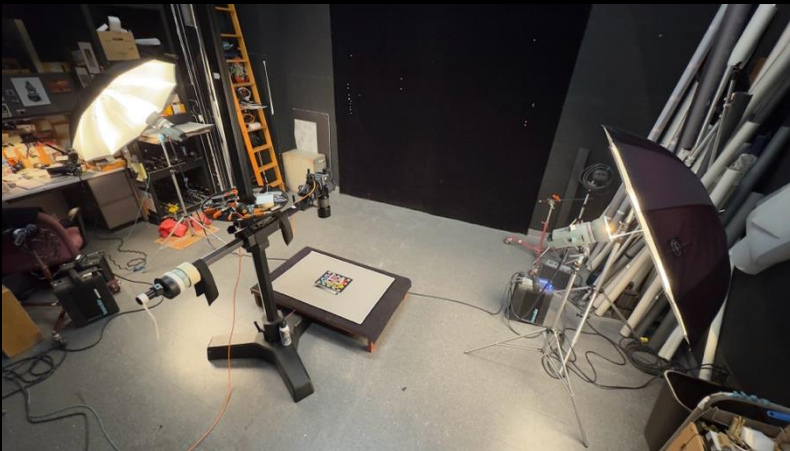
# Converging Imaging Standards



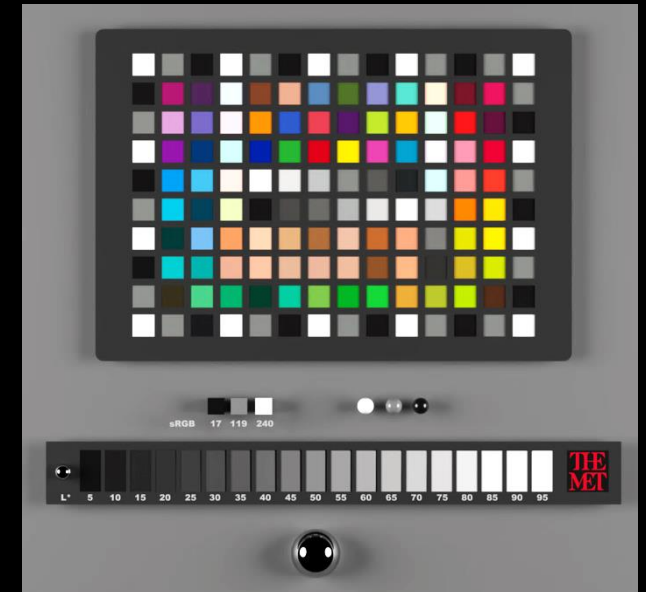
ISO Still Imaging Working Group



# Leveraging 2D standards for 3D Image Quality

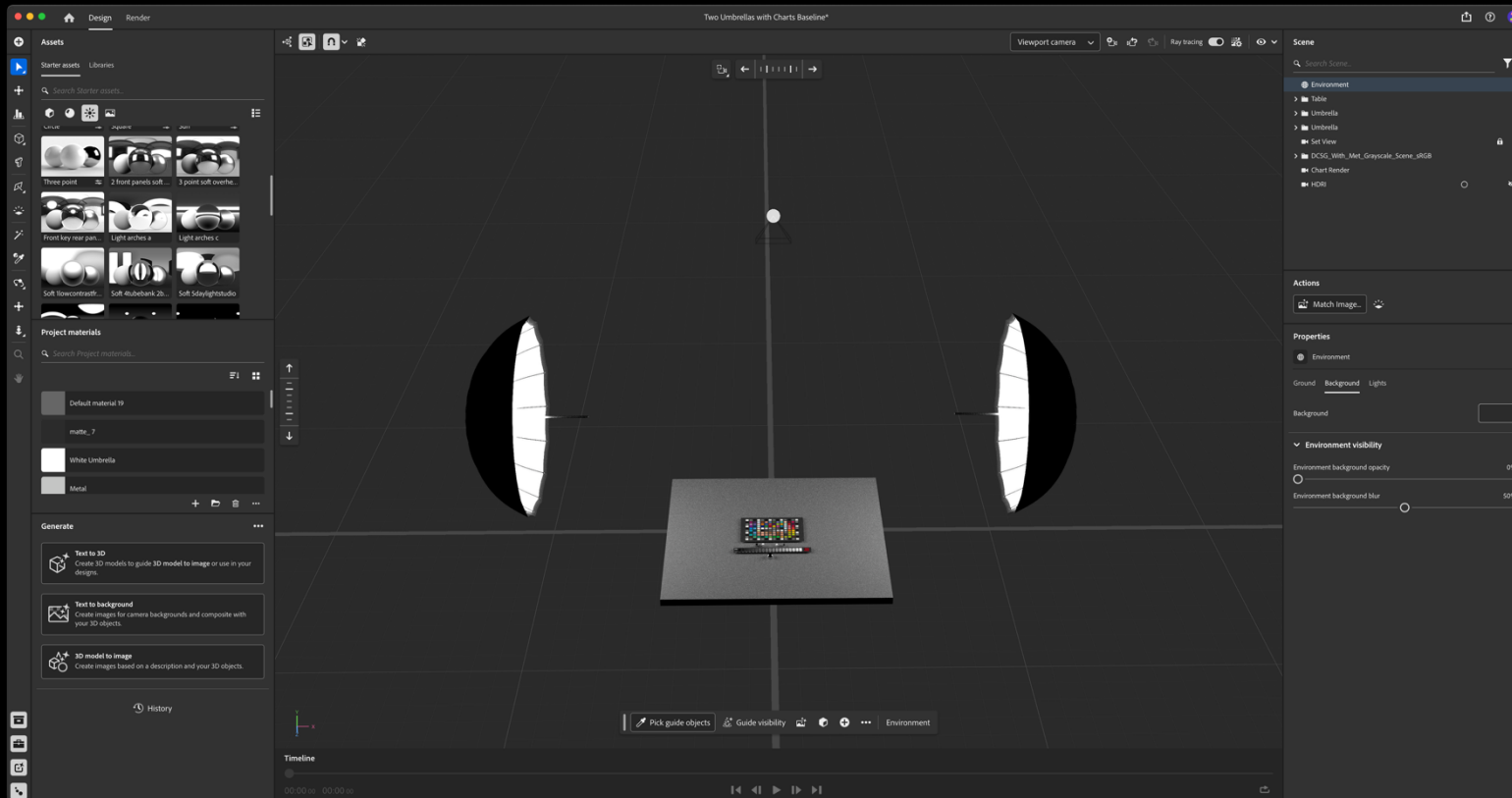


Physical Charts & Lighting Set



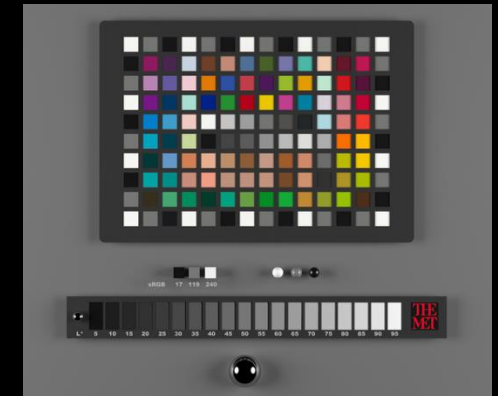
Digital Charts

# Leveraging 2D standards for 3D Image Quality

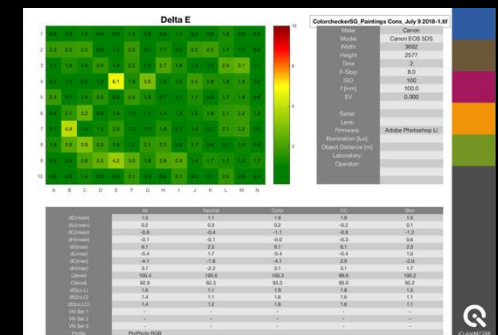


Copy Stand Scene

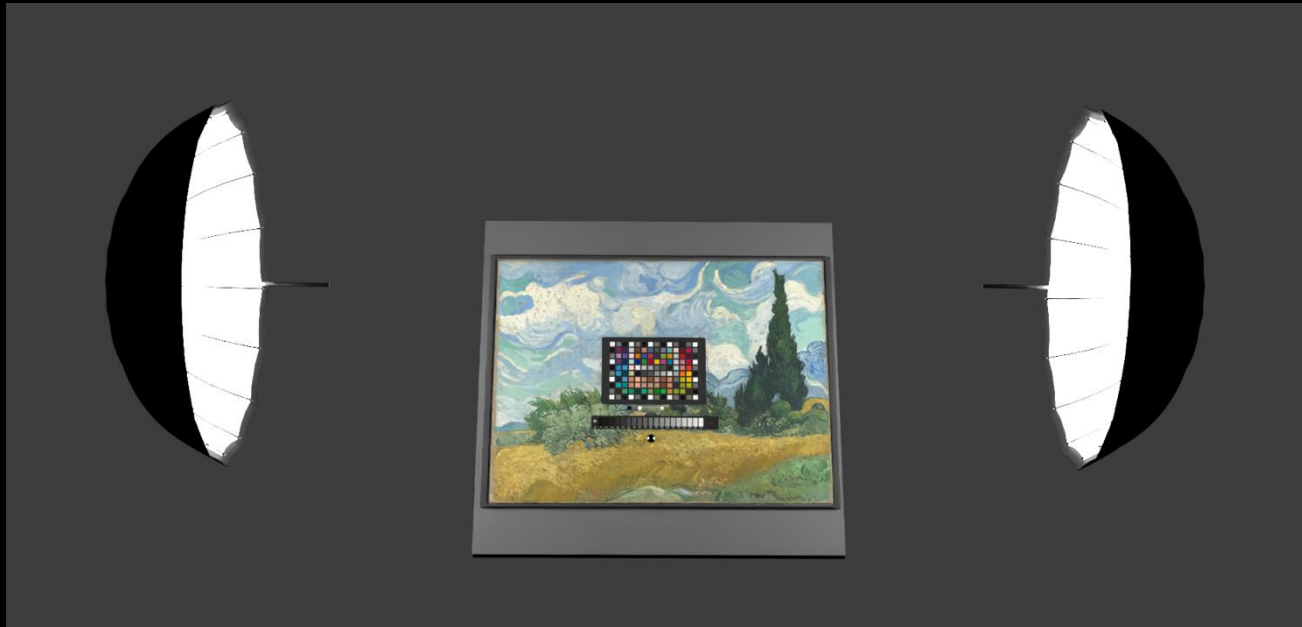
Chart Scene Render



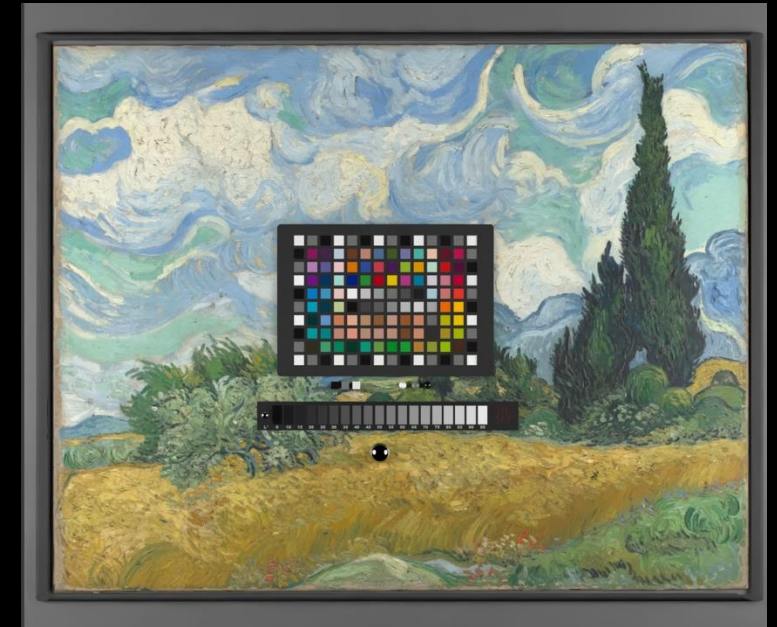
Validation Report



# Leveraging 2D standards for 3D Image Quality



Virtual Set (Validated Exposure / Color)

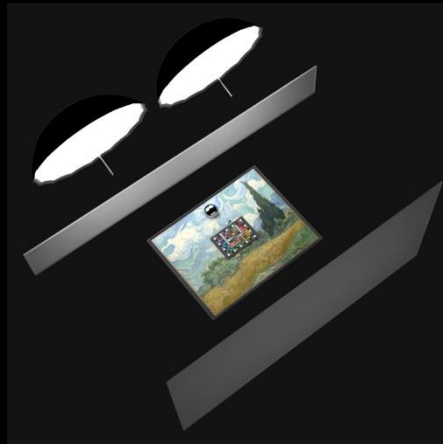


3D Model (render)

# Leveraging 2D standards for 3D Image Quality



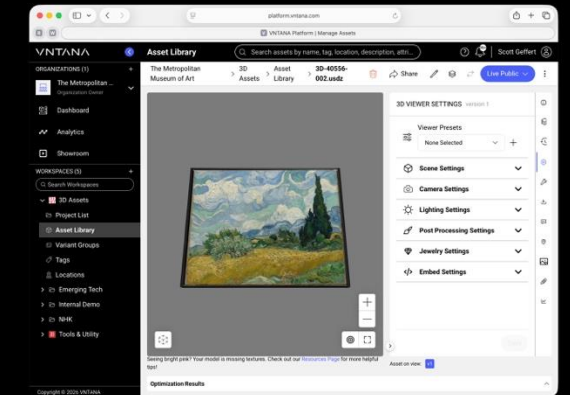
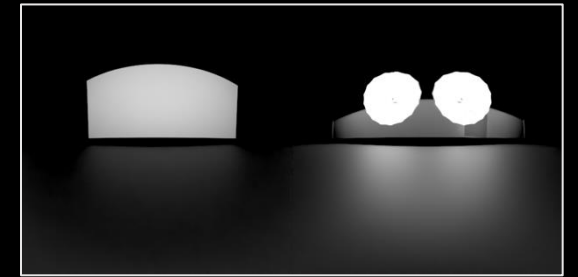
Original Photographic Lighting



Virtual Set

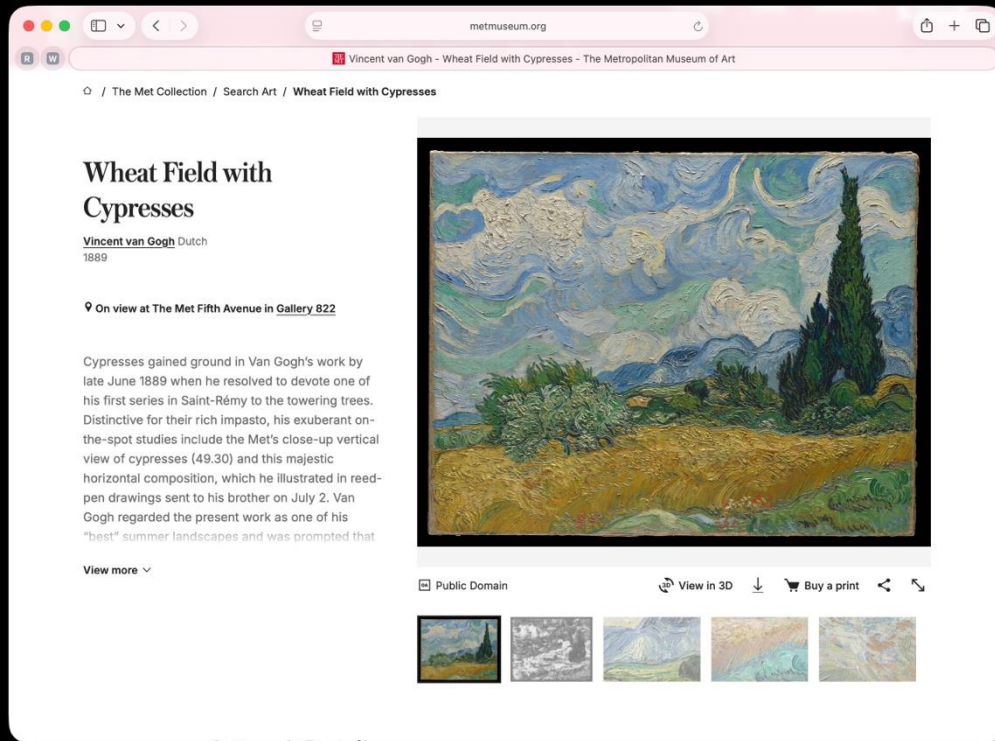


3D Model (render)

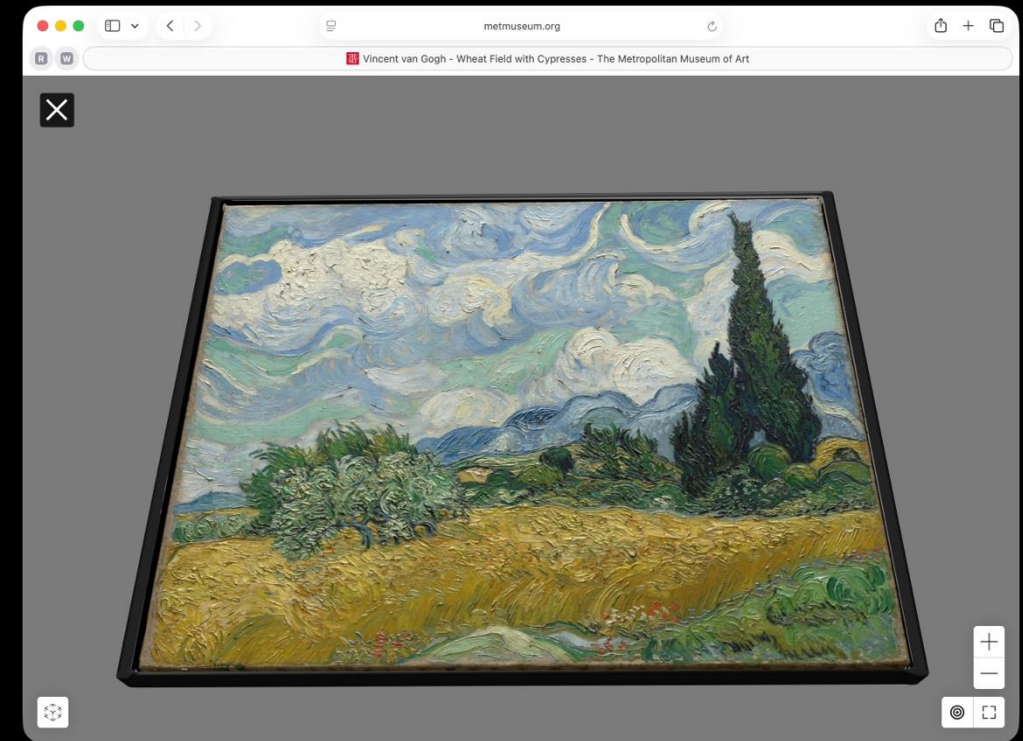


Web Rendition + Custom HDRI

# Leveraging 2D standards for 3D Image Quality



Online Collection 2D Photography



Online Collection 3D Model

# Leveraging 2D standards for 3D Image Quality



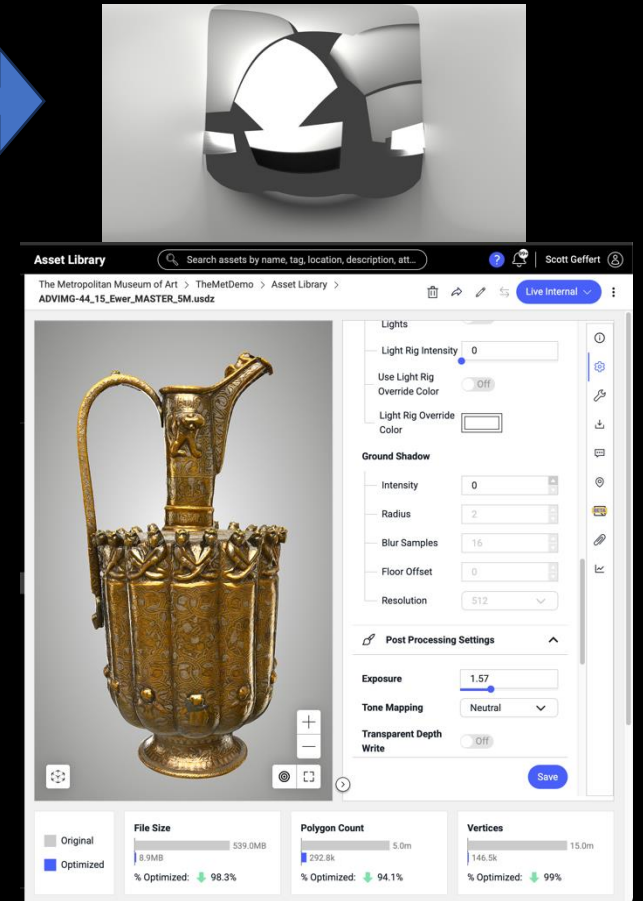
Original Photograph



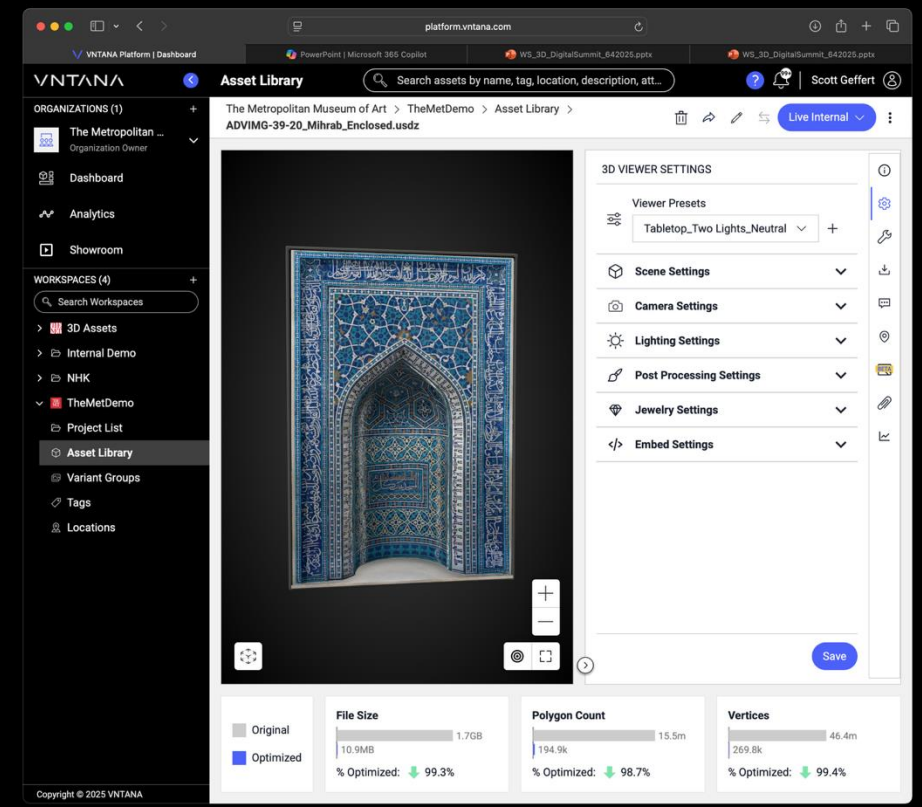
Virtual Set



3D Model (render)



Web Rendition + Custom HDRI 27



# Van Gogh Sunflowers 2026



# Van Gogh Sunflowers 2026

Nick Porcino-Principal Engineer, Pixar Animation Studios  
Michael B Johnson (Wave) Innovation Architect, Apple Computer  
Jeremie Noguer - Substance 3D Ecosystem Product Director, Adobe  
Michael Min - Sr. 3D Graphics Engineering Manager, Adobe  
Vincent Gault - Substance 3D Product Manager, Adobe  
Jeanette Chow - Principal Product Manager, Adobe  
Erin Kim - Sr Staff Designer, Adobe  
Selena Lounds - Mgr, Program Management, Adobe  
Andre Mazzone-Head of Engineering, Industrial Light and Magic



# Van Gogh Sunflowers 2026

## Goals:

- Create a new 2D reference photograph
- Create a new 3D model
- Capture new spectral reference measurements
- Deliver consistent online rendition of 2D and 3D
- Share the process with the community

# Van Gogh Sunflowers 2026

## 2D Photography:

Camera: Hasselblad X2D100C

Lighting: Broncolor Electronic Flash

Lighting Geometry:

Umbrellas, Spun Glass, Bounce Fill



# Van Gogh Sunflowers 2026

## 3D Photography:

Camera: Hasselblad X2D100C

Lighting: Broncolor Electronic Flash

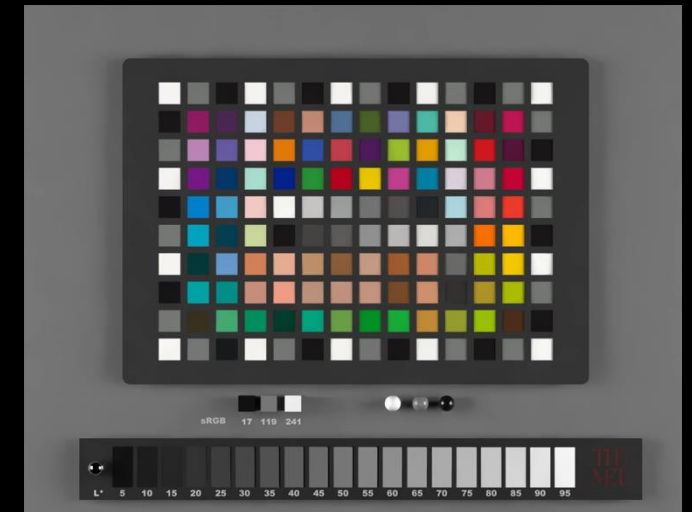
Lighting Geometry: Diffuse, Uniform



# Van Gogh Sunflowers 2026

## Camera Color Characterization:

Color Validation: ISO 19264 (DCSG + Linear Grayscale)  
 Analysis Software: Image Engineering-IQ Analyzer  
 Image Encoding: Tiff 16bit ProRGB  
 Spectral Validation: Myiro Spectrophotometer  
 Babbelcolor Patch Tool (L\*a\*b\* to RGB patch generation)

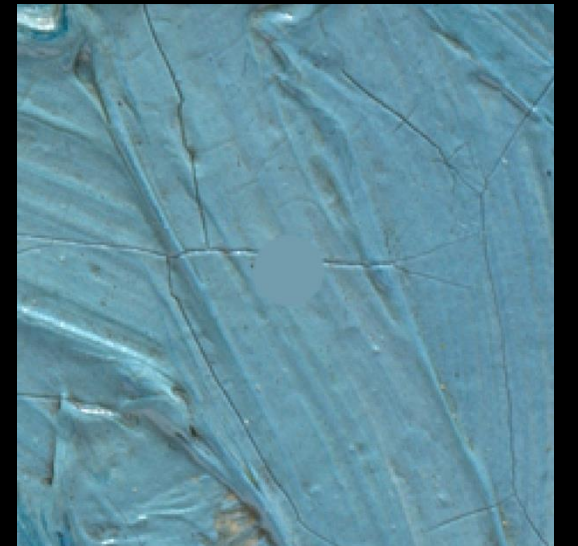
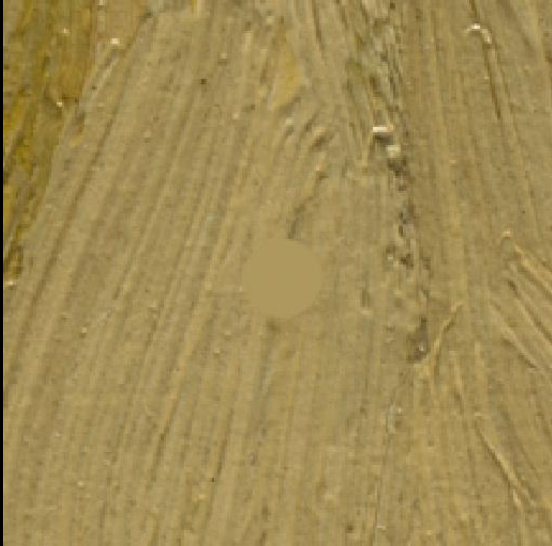


Delta E Numerical Results

|    | A       | B       | C       | D       | E       | F       | G       | H       | I       | J       | K       | L       | M       | N       |
|----|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| 1  | 0.4 A1  | 0.9 B1  | 0.4 C1  | 0.3 D1  | 0.9 E1  | 0.8 F1  | 0.3 G1  | 0.9 H1  | 0.2 I1  | 0.4 J1  | 0.9 K1  | 0.5 L1  | 0.9 M1  | 0.5 N1  |
| 2  | 0.4 A2  | 0.1 B2  | 0.3 C2  | 0.5 D2  | 0.2 E2  | 0.1 F2  | 0.1 G2  | 0.0 H2  | 0.3 I2  | 0.2 J2  | 0.3 K2  | 0.2 L2  | 0.2 M2  | 0.9 N2  |
| 3  | 1.0 A3  | 0.3 B3  | 0.2 C3  | 0.5 D3  | 0.3 E3  | 0.1 F3  | 0.2 G3  | 0.3 H3  | 0.2 I3  | 0.2 J3  | 0.3 K3  | 0.1 L3  | 0.4 M3  | 0.6 N3  |
| 4  | 0.2 A4  | 0.2 B4  | 0.1 C4  | 0.4 D4  | 0.2 E4  | 0.2 F4  | 0.3 G4  | 0.3 H4  | 0.2 I4  | 0.2 J4  | 0.4 K4  | 0.3 L4  | 0.3 M4  | 0.4 N4  |
| 5  | 1.2 A5  | 0.1 B5  | 0.2 C5  | 0.6 D5  | 0.3 E5  | 0.9 F5  | 0.6 G5  | 0.9 H5  | 1.5 I5  | 0.9 J5  | 0.5 K5  | 0.3 L5  | 0.3 M5  | 0.9 N5  |
| 6  | 0.3 A6  | 0.3 B6  | 0.2 C6  | 0.4 D6  | 0.9 E6  | 1.0 F6  | 0.7 G6  | 0.9 H6  | 0.3 I6  | 0.5 J6  | 0.2 K6  | 0.4 L6  | 0.2 M6  | 0.4 N6  |
| 7  | 0.3 A7  | 0.1 B7  | 0.3 C7  | 0.1 D7  | 0.1 E7  | 0.3 F7  | 0.1 G7  | 0.1 H7  | 0.4 I7  | 0.4 J7  | 0.6 K7  | 0.5 L7  | 0.2 M7  | 0.4 N7  |
| 8  | 0.4 A8  | 0.5 B8  | 0.3 C8  | 0.4 D8  | 0.4 E8  | 0.2 F8  | 0.2 G8  | 0.3 H8  | 0.5 I8  | 0.1 J8  | 0.5 K8  | 0.2 L8  | 0.1 M8  | 0.9 N8  |
| 9  | 0.3 A9  | 0.6 B9  | 0.2 C9  | 0.1 D9  | 0.6 E9  | 0.3 F9  | 0.1 G9  | 0.3 H9  | 0.3 I9  | 0.4 J9  | 0.9 K9  | 0.2 L9  | 0.1 M9  | 0.6 N9  |
| 10 | 0.5 A10 | 1.0 B10 | 0.9 C10 | 0.5 D10 | 0.3 E10 | 0.4 F10 | 0.5 G10 | 0.2 H10 | 0.7 I10 | 0.4 J10 | 0.8 K10 | 1.0 L10 | 1.0 M10 | 0.4 N10 |



# Van Gogh Sunflowers 2026



# Van Gogh Sunflowers 2026

## 3D Processing:

Raw Processing- Color Characterization: Hasselblad Phocus

Photogrammetry Processing: Metashape Pro

Material Estimation (Frame): Kintsugi

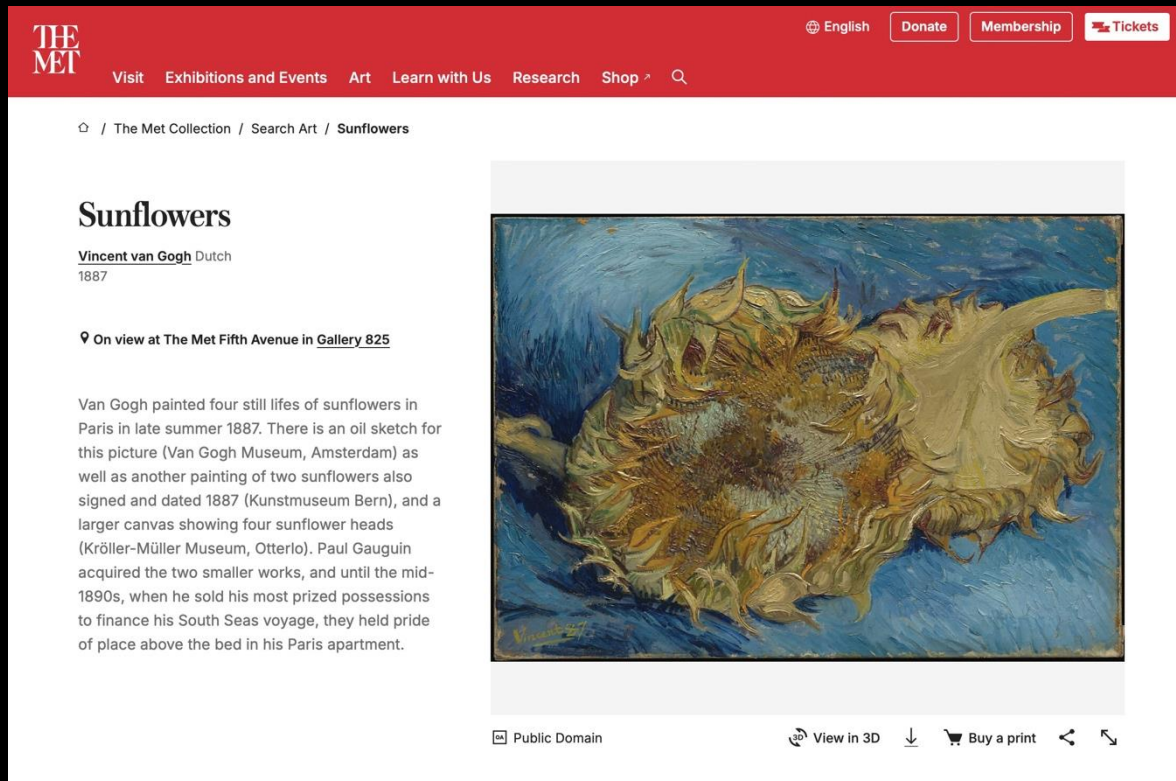
Spot Color Validation: Adobe Photoshop / Excel

Adobe Stager: 3D Scene Lighting, Rendering

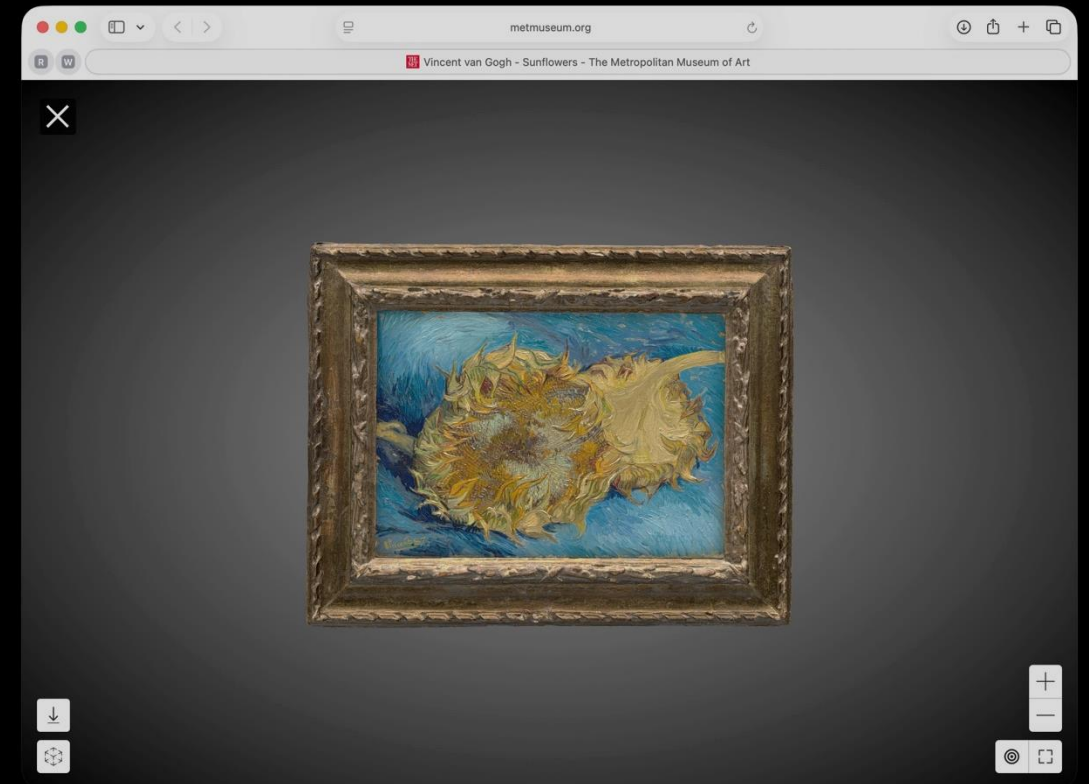
Blender: HDRI Generation

Vntana: Web Optimization, Web Delivery

# Van Gogh Sunflowers 2026



Collection. Page 2D



Collection. Page 3D

<https://www.metmuseum.org/art/collection/search/436524>

# Van Gogh Sunflowers 2026

## Findings:

- ISO 19264 successfully translates to 3D imaging
- Need to standardize material capture techniques
- Need standards for physically accurate light units
- Need to sort out capture to output HDR color validation
- Need standards for physically accurate cameras
- Need Improved studio materials (diffusion scrims, reflectors)
- Need Metadata, Content Authenticity etc.
- Need to develop best practice between 2D and 3D color

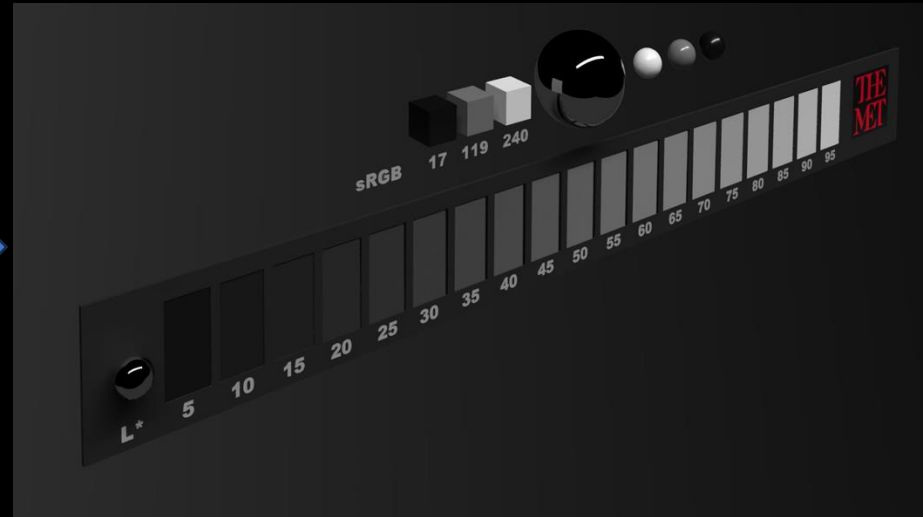
# Van Gogh Sunflowers 2026



# Building Global Communities



Hans Van Dormolen:  
A key figure in standardizing cultural  
heritage image quality assessment



Nick Porcino-Pixar  
A key figure in the development of  
3D Standards via OpenUSD



# Thank You!



Van Gogh Article



Reference Asset Paper



Unicorn Tapestries  
Article



ISO 19264  
Standard