

In situ recording and displaying true-color
holographic optical clones (OptoClones[®]) of cultural
artifacts in Museums.

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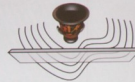
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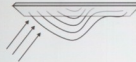
IS IT POSSIBLE?



- A. An observer interacting with the light waves from an object perceives the object in 3D.



- B. A suitable storage medium encodes and stores permanently the light wavefronts .



- C. The object is removed and the storage medium reconstructs, upon proper illumination, the stored wavefronts.



- D. An observer interacting with the **reconstructed waves** perceives the object **as really existing** behind the storage medium!

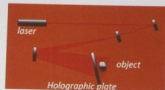
HOLOGRAPHY

Recording and reconstructing wavefronts

In 1962, Dr. Y.N. Denisyuk from Russia combined holography with 1908 Nobel Laureate Gabriel Lippmann's work in natural color photography.

Denisyuk's technique produced a reflection hologram which, for the first time, could be viewed under ordinary incandescent bulb light.

By using 3 or more laser lines, one can record quality color Denisyuk holograms of artifacts .



Denisyuk single beam reflection hologram recording .



Recording



Reconstruction

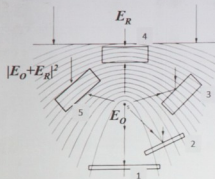


Photo of hologram

These holograms are viewable under white light illumination.

HOLOGRAPHY

The basic equations



The intensity of the interference pattern between the object field E_O and the reference field E_R is:

$$|E_O + E_R|^2 = E_O E_R^* + |E_R|^2 + |E_O|^2 + E_O^* E_R$$

The transmittance T of the exposed and developed silver halide plate (hologram) is proportional to the intensity of the interference pattern:

$$T = k|E_O + E_R|^2 = kE_O E_R^* + k|E_R|^2 + k|E_O|^2 + kE_O^* E_R$$

1,2,3 Transmission holograms. 4,5 Reflection holograms

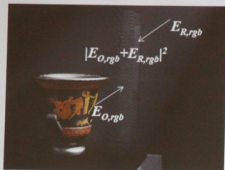
Finally if we illuminate the hologram with the **reference wave** E_R then the hologram will diffract the complex field E_H :

$$E_H = TE_R = kE_O |E_R|^2 + k|E_R|^2 E_R + k|E_O|^2 E_R + kE_O^* E_R^2$$

The first term of E_H is a **duplicate** of the object field E_O (*wavefront reconstruction of the object field*). The fourth term is the **time reversed** object field. All four terms are angularly separated in positions 2,3,5.

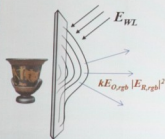
HOLOGRAPHY

Single beam (Denisyuk) color reflection holograms



A silver halide plate is exposed to the interference fringes $|E_{O,rgb} + E_{R,rgb}|^2$ of the reference and object fields of RGB laser light.

It records three distinct interference patterns corresponding to the three laser wavelengths. The fringes spacing of each pattern is $\lambda_i/2$, where λ_i the wavelength of each laser.



The finished hologram selectively reflects out of a beam of white light E_{WL} (coming from the same angle as the reference $E_{R,rgb}$) the wavelengths that match the Bragg's diffraction condition $n\lambda_i = 2d \sin\theta_i$.

These wavelengths match the wavelengths of the three laser used during recording. The reflected field $E_{H,rgb}$ contains the reconstruction of the object field:

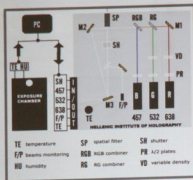
$$kE_{O,rgb} |E_{R,rgb}|^2$$

Theoretical and Practical Considerations

Color Denisyuk holograms of high quality can be recorded in silver halide emulsions, in museums, if certain prerequisites are fulfilled e.g. :

- Suitable selection of three or more laser wavelengths
- Panchromatic recording plates with mean grain size well below 10 nm
- Optimized processing of the exposed plates
- Suitable recording geometry to eliminate dispersion
- Mechanical and thermal stability
- Optimized illumination of the color hologram to enhance depth reconstruction, color rendition and minimize blur
- Transportable recording systems instead of massive laboratory isolation tables and lasers.

Our approach: The Z3 RGB system

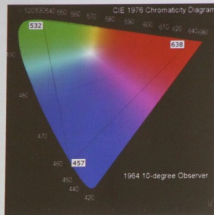


Transportable.
Vibration and thermal
isolation.

ISDH2015, Saint-Petersburg, Russia

HIH

Our approach: Laser wavelengths



Light sources made up of **different mixtures** of various wavelengths **may appear to be the same color**; this effect is called **metamerism**. Such light sources have the same **apparent color** to an observer when they produce the same tristimulus values. Suitable selection of 3 wavelengths would cover a sufficient area of the CIE chromaticity diagram. We use lasers at 457, 532 and 638 nm .

Why ?

Close matching to the emission characteristics of available power LEDs for our HoLoFoS hologram illuminating device **and** the spectral response of the human eye.









Our approach: Stability



Electronic control and monitoring of all exposure parameters.
Continuous laser mode lock monitoring.
Two stages passive isolation platform.
Specially designed mobile tent chamber that encloses the object/plate space in order to minimize air currents and ensure thermal stability during the exposures.

Our approach: Illumination

HELLENIC INSTITUTE OF HOLOGRAPHY

COMMON RGB	HoLoFoS V.1	HoLoFoS V.2	HoLoFoS V.3
			
MIXING PROFILE 3 angularly displaced beams considerable angular separation	MIXING PROFILE 3 angularly displaced beams small angular separation	MIXING PROFILE 3 coaxial beams mixed with a dichroic cube	MIXING PROFILE 3 coaxial beams mixed with 2 dichroic combiners
			
CHARACTERISTICS Narrow bandwidth High level of blur Must be placed far from a hologram May support intensity mixing	CHARACTERISTICS Narrow bandwidth Lower level of blur Must be placed far from a hologram Smart control with intensity mixing	CHARACTERISTICS Narrow bandwidth Minimal level of blur Can be placed close to a hologram Smart control with intensity mixing	CHARACTERISTICS Narrow bandwidth Minimal level of blur Can be placed close to a hologram Smart control with intensity mixing

'HoLoFoS' is our intelligent LED illuminating device that can supply to a hologram the necessary narrow bandwidth in red, green and blue light with peaks near the recording wavelengths. The HoLoFoS III provides coaxial mixing of the LEDs beams with the use of dichroic combiners.

RESULT: OptoClones®

- One-to-one size depiction
- Natural colour (RGB)
- Full detail (surface texture) and contrast
- LASER light resolution (nm)
- Full Parallax (vertical / horizontal)
- 180 degrees viewing angle
- Moving light reflections
- Perfect light shadows



In
exhibition
at the



2012 -
2015

If accessible only through vision, the object is really present for the human brain with its optical replica indistinguishable from the original object

Byzantine and Christian Museum



BYZANTINE & CHRISTIAN MUSEUM
Hellenic Ministry of Culture and Sports

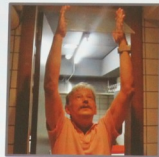
A WORLD'S FIRST

- In August 2013 the **Hellenic Institute of Holography** recorded in the Byzantine & Christian Museum of Athens the OptoClones[®] of twelve objects of the museum's collections using the Z3^{RGB} transportable system.
- **These OptoClones[®] were displayed in place of the original objects for the period that the original objects were on loan to the United States.**
- The OptoClone[®] of Saint Mamas eulogy was also recorded. This hologram was in display during the "Veneration of Saint Mamas in the Mediterranean: A Traveler Border –Defendder Saint" exhibition, MBC, Oct.2014 .
- HoLoFos devices were used for the optimized illumination of the OptoClones[®]
- Holographer: Andreas Sarakinos
- Ultimate plates

OptoClones® at the

B X M
BYZANTINE & CHRISTIAN MUSEUM
Hellenic Ministry of Culture and Sports

Athens
Aug2013



HiH
Hellenic Institute of Heritage

OptoClones[®] at the



BYZANTINE & CHRISTIAN MUSEUM
Hellenic Ministry of Culture and Sports

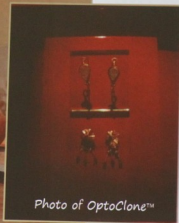


Photo of OptoClone™

Pairs of golden Ear-rings
(3rd - 4th c. AD)

ISDH2015 , Saint-Petersburg , Russia



OptoClones[®] at the



BYZANTINE & CHRISTIAN MUSEUM
Hellenic Ministry of Culture and Sports



- Silver Ladle 7th c. AD
- Silver Plate 7th c. AD
- Lamp-stand 7th c. AD

Photos of OptoClones™

ISDH2015 , Saint-Petersburg , Russia



OptoClones[®] at the



BYZANTINE & CHRISTIAN MUSEUM
Hellenic Ministry of Culture and Sports



Thursday, Sep 12, 2013

(We have opted to use display holograms – instead of digital media- for the visual replacement of selected cultural artifacts during their temporary loan as) we felt that their **one-to-one** ultra-realistic 3D optical representation through full-colour holography allows the viewer to form an **accurate** view of the object –even when the original artifact is not present. Moreover, this happens **instantly** at first glance without any interaction or complications introduced by the digital media (touch screens, buttons, image quality etc.).

Nikos KONSTANTIOS, Archaeologist, Museologist,
BYZANTINE & CHRISTIAN MUSEUM, Athens.

OptoClones® at the



Latest assessment

- ✓ The technique enhances the accessibility to the museum's collections and opens new possibilities in the cases of loans.
- ✓ The museum considers organizing new types of exhibitions either using holograms and original artifacts, or solely holograms.
- ✓ The display of OptoClones in place of the artifacts on loan seems to contribute to the increased number of visitors during the last months.

Nikos KONSTANTIOS, Archaeologist, Museologist.
BYZANTINE & CHRISTIAN MUSEUM, Athens.
May 2014

OptoClones® at the



Thessaloniki, Sep2013

- In September 2013 the **Hellenic Institute of Holography** recorded in the **Thessaloniki Museum of Byzantine Culture** OptoClones® of Saint Mamas icon and selected objects of the museum's collections using the Z3^{RGB} transportable system.
- The **Saint Mamas OptoClone®** was in display during the "Veneration of Saint Mamas in the Mediterranean: A Traveler Border –Defendder Saint" exhibition, **MBC, Oct.2014** .
- HoLoFos Illumination
- Holographer: **Andreas Sarakinos**
- Ultimate plates

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Hellenic Institute of Holography

OptoClones® at the Faberge Museum SpB

- In May 2013 the Hellenic Institute of Holography recorded in the Faberge Museum ,SpB, **OptoClones® of thirteen imperial eggs** using the Z3^{RGB} transportable system.
- The Faberge Eggs OptoClones® will be displayed in the exhibition Magic of Light in Saint Petersburg, Russia (June-October 2015)
- Holographer: Andreas Sarakinos
- Mostly BBpan plates , few Ultimate



CONCLUSION

We believe that an holistic approach to color holography, such as our OptoClones[®], will assist in generating a new interest in museum applications of holography .

Thank you

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