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

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ISDH2015, Saint-Petersburg, Russia
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.

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:

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

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

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

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

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

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 $\lambda_i$ 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

Mobile darkroom
Exposure chamber

Recording an OptoClone

Transportable. Vibration and thermal isolation.

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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 metamericism. 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.

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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.

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Our approach: Illumination

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

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

In exhibition at the MIT museum 2012-2015

This is photo of an OptoClone®

ISDH2015, Saint-Petersburg, Russia
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 Z3RGB 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 – Defender Saint” exhibition, MBC, Oct.2014.
• HoLoFos devices were used for the optimized illumination of the OptoClones®
• Holographer: Andreas Sarakinos
• Ultimate plates

ISDH 2015, Saint-Petersburg, Russia
OptoClones® at the Byzantine & Christian Museum, Athens, Aug 2013
OptoClones® at the

Pairs of golden Ear-rings
(3rd - 4th c. AD)
OptoClones® at the

(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.

Thursday, Sep 12, 2013

ISDH2015, Saint Petersburg, Russia
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, Sep 2013

- 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 Z3RGB transportable system.
- The Saint Mamas OptoClone® was in display during the “Veneration of Saint Mamas in the Mediterranean: A Traveler Border – Defender Saint” exhibition, MBC, Oct. 2014.
- Holofos Illumination
- Holographer: Andreas Sarakinos
- Ultimate plates

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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 Z₃RGB 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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