Colour Holography for the documentation and dissemination of cultural heritage:
OptoClones™ from four Museums in two countries

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Wave-front reconstruction

recording laser light waves reflected off an object, stored on a glass plate and recreated later on.
Holograms of cultural artifacts ...

Gold collar, Falbygdens Museum in Ålleberg, **Sweden, 1980** by Hans Bjelkhagen

The ‘Lindow Man’
**British Museum, 1987**
by Richmond Holographic Studios

... for display at the Museum
Soviet scientists used monochrome holography in the 80s to bring “art to the people”

Ancient Greek vase
60x80 cm, Hermitage (1985)

‘Christ the Saviour’
18th c. Ukraine

‘Virgin of Kazan’,
18th c. from Suzdal Museum
Russian 1983 Monochrome Hologram

Original Monochrome Denisyuk reflection hologram on early production PE-2 (Slavich) glass plate. Size 40x28 cm landscape, by M. Shevtsov


Courtesy of Hans Bjelkhagen
Minsk, Belarus

‘St. Philip the Apostle’ Russian Orthodox church, Sharjah UAE
Full Colour
Theoretical and Practical Considerations

**Full-colour** Denisyuk-holograms of high quality can be recorded in silver halide emulsions, 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 colour hologram to enhance depth reconstruction, colour rendition and minimize blur
- **Transportable recording system** instead of massive laboratory isolation tables and lasers.
**Museum Artefacts Recorded in a Laboratory**

*Bringing the Artefacts Back to the People* was a UK project to record colour holograms for a touring exhibition. One of the first artefacts to benefit under this project was the 14,000-year-old *Decorated Horse Jaw Bone* from the ice age. The bone is the only piece of artwork dated to the end of the last Ice Age or Late Glacial period in Britain. It was dug up by Thomas Kendrick in 1880 and is kept at the *British Museum* in London.

The *OptoClone* of the horse jaw bone was recorded at the Centre for Modern Optics (CMO) in Wales on 21 April 2009.
Decorated Horse Jaw Bone Recording

Jill Cook, British Museum
Peter Crosby, Hans Bjelkhagen,
Ardie Osanlou, CMO

Horse Jaw positioned under the recording plate

Recording of the *Horse Jaw OptoClone* at CMO

Courtesy of Hans Bjelkhagen
Decorated Horse Jaw Bone OptoClone

Photo of the OptoClone

Courtesy of Hans Bjelkhagen
HOLOGRAPHY
Recording and reconstructing wave-fronts

Recording

Reconstruction

Photo of hologram
by Yves Gentet
Cultural Artifacts

WEDH Minsk-2011
Hologram of Ceramic Vase

Photo of hologram
by Yves Gentet
Cultural Artifacts

Hologram of Cycladic Idol

Object under disperse light

Object under white laser light

Photo of hologram by COLOUR HOLOGRAPHIC
Cultural Artifacts

WEDH Minsk-2011
Hologram of Cycladic Idol
MUSEUM in a SUITCASE

A museum in a suitcase

Three-dimensional 'replicas' of works of art, produced by the astonishing technique of holography

by Vl. Markov / Iv. Yavtushenko

March 1981
Mobile Recording Equipment

To introduce this new ultra-realistic imaging technique to museums and make it feasible for them to use it, it is essential to use mobile holographic recording equipment.

It would be out of question to bring very rare and expensive artefacts to a holographic laboratory.

Today we have many small powerful lasers on the market which makes such equipment possible to develop.
Our approach: The Z3\textsuperscript{RGB} system
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 tri-stimulus 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.
ZZZyclops™ Recording Equipment
Mobile Hologram Recording Principle
Transportability: the Z3\textsuperscript{RGB} system

Transportable.
Vibration and thermal isolation.
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.
Light for Illuminating Colour Holograms

The selection of a suitable lamp for the correct reconstruction (illumination) of colour holograms is much more critical than the selection of lamps for monochrome hologram display.

The colour balance for the recording of a colour hologram must be adjusted with the type of light that is going to be used for the display of the finished hologram in mind.

Colour reproduction in a reflection hologram is only correct when the light is illuminating the hologram at a specific angle.
Layman's diagram showing the importance of using a point source light to illuminate a hologram. Here we make an analogy to the shadow cast by a spotlight on a screen. In (a) the spotlight emits light from a small point, resulting in a sharp image. In (b) a large-area diffuse spotlight results in a diffuse image. In (c) many spotlights illuminate the hologram, resulting in multiple images.
Our approach: **HoLoFoS-λ**

‘**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-λ** provides coaxial mixing of the LEDs beams with the use of dichroic combiners.
Proprietary LED illuminants

OptoClon

As unique as the origina

1 + 2

Tuned pair

Ultra-realistic holograms of art objects

OptoClones™ is a registered trademark of the Hellenic Institute of Holography. All rights reserved.
OptoClones™

- One-to-one size depiction
- Natural colour rendition (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
- Full replication of optical properties of object

If accessible only through vision, the object is really present for the human brain with its optical replica indistinguishable from the original object.
What is an Ultra–Realistic Image?

- It looks “identical” to the real object as observed by eye
- Very accurate colour rendition
- Same scale – no magnification
- Resolution corresponds to the eye resolution
- No detectable image blur (spatial or chromatic)
- No field of view limitations
- Image light reflections move like they do on the object

- ONLY HOLOGRAPHY can accomplish this and is now referred to as an OptoClone
Work in Museum
Single-shot

HiH
The (Thessaloniki) Museum of Byzantine Culture

In 2005, the museum was awarded the Council of Europe's Museum Prize

October 2013

On Jan 19th, 2014 the temporary exhibition titled "The Veneration of St. Mamas in the Mediterranean: A Traveler Border-Defender Saint" organized by the Thessaloniki Museum of Byzantine Culture (MBC) as part of the 4th Biennale of Contemporary Art came to a successful end.
OptoClones™ at the

Thessaloniki Oct2013
OptoClone of the Golden Bracelet 9-10c. AD, originated in-situ at the Thessaloniki Museum of Byzantine Culture in Oct2013 by A. Sarakinos
‘Heaven and Earth’: Art of Byzantium from Greek Collections

At National Gallery of Art, Washington from October 6, 2013, through March 2, 2014; Travels to the J. Paul Getty Museum, Los Angeles,

Some 170 rare and important works, drawn exclusively from Greek collections, will offer a fascinating glimpse of the soul and splendor of the mysterious Byzantine Empire. Recognized masterpieces, many never lent before to the United States, will be on view with newly discovered and previously unpublished objects from recent archaeological excavations in Greece.
OptoClones™ at the

Athens Aug 2013
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.
OptoClones at the Byzantine & Christian Museum

Golden Treasure of Mytilini 7th c. AD

Photo of OptoClone™
OptoClones at the

Pair of Silver Ear-rings
(9th - 10th c. AD)

Photo of OptoClone™
The Fabergé Collection of OptoClones™

Made by HiH

In collaboration with ITMO University

Sponsored by J.V. Bowater

A world’s first
The Fabergé Egg OptoClone Project

The *Forbes Fabergé collection* in the USA contained nine of the Imperial Easter Eggs. In 2004 these eggs were acquired by *Viktor Vekselberg* for about $120 million. He brought them to Russia to be displayed to the general public in St. Petersburg. In November 2013 the Eggs were finally put on display at the new *Fabergé Museum* located in the Shuvalov Palace in the centre of St. Petersburg. The museum contains a total of approximately 4000 works of fine art and decorative applied art, including gold and silver items, paintings, porcelain, and bronze.
A multi-national project
June 2014 with
H. Bjelkhagen and M. Richardson

Sep 2014
V. Vasilyev (ITMO University)
V. Voronchenko (Lnk of Times)
A. Lembessis, (HiH)
• Transportable proprietary equipment
• Special holographic glass plates

Panchromatic high-resolution silver-halide
Fabergé Egg and OptoClone

The 15th Anniversary Egg in the museum display

Photo of OptoClone™ of the “15th Anniversary” Fabergé Imperial Egg
Display

International Year of Light

ITMO University

Magic of Light
A collection of 13 *OptoClones™*

Optical Documentation - Ready to Travel
Best of Year 2015
The Collection of OptoClones™ of Russian State Treasures

Made by HiH

In collaboration with ITMO University

Commissioned by Gokhran of Russia

the Diamond Fund

Another world’s first
A multi-national project
Unofficial photos. For documentation only.
• Transportable proprietary equipment

Chemistry room

Dark room
• Transportable proprietary equipment

Dark room

ZZZyclops
• Transportable proprietary equipment

Chem Lab

Dark room
• Security
• Security
• Time for the objects
St. Alex.Nevsky Order (Badge)
Gokhran of Russia, 1795

Is it realistic?
Cesar’s Ruby (Pendant)
Gustav III (1777); Gold, Pink tourmaline-rubelite (52.00 carats), enamel
Gokhran of Russia

Unofficial photos.
For documentation only

Is it ultra-realistic?
Bow-Esclavage
L. Pfistener (1764); Gold, silver, diamonds, spinels
Gokhran of Russia

Unofficial photos.
For documentation only

Is it ultra-realistic?
Order of St. Catherine (Badge & Cross)
Karl Ghana jewelers (1904); Gold, silver, diamonds, enamel
Gokhran of Russia

Unofficial photos
For documentation only

Photo of original Object (iPhone6)

Photo of OptoClone™ (S7)

Is it ultra-realistic?
Rattle-Whistle (Toy)
S. Larionov, M. Belsky (1740); Gold, silver, diamonds, rubies, emeralds, ivory
Gokhran of Russia

Unofficial photos.
For documentation only

Is it ultra-realistic?
A collection of 11 OptoClones™

Optical Documentation - Ready to Travel (for exhibition)
• Display

On Stage
• OptoClones in Moscow Kremlin

Andreyevsky Hall, 16 Nov 2017
At that time, they were kept
2-D Art Reproduction

It may sound strange, but actually, recording OptoClones may become an important reproduction technique for 2-D objects as well, such as, e.g. oil paintings – providing extremely realistic-looking images, showing the texture details such as brush strokes and the painter's signature. In addition, they will not fade or change colour even if they are continuously on display.

This fact is of importance from an archival point of view as well. Insurance companies may require reproductions of very expensive works of art in case they are stolen or damaged. If perfect colour rendering can be obtained in OptoClones, accurate 2-D art reproduction may become important in the future.

Courtesy of Hans Bjelkhagen
Enlarged Areas of the Painting

Detail of the oil painting *OptoClone*

Original

*OptoClone*

Courtesy of Hans Bjelkhagen
Clones of Works of Art

Tretyakov Gallery
Moscow, Russia (20 June 2018)
OptoClones™
Optical Clones of Works of Art

‘Little House in the Prairies’ by P. Kaziridis
Oil on Canvas, 25x25cm (Greece, 2013)
‘Little House in the Prairies’ by P. Kaziridis
Oil on Canvas, 25x25cm (Greece, 2013)
... a multi-dimensional document
‘Seeing is believing’…

INTERMUSEUM-2018, VDNH Moscow,
Pavillion 75, booth #48

… is it really?
For More Information

www.hih.or.gr

Credits

✓ Andreas Sarakinos (HiH)
✓ Kostas Sarakinos (HiH)

✓ Sergey Stafeev (ITMO)
✓ Elena Bobritskaya (ITMO/OPTIMUS)
✓ Mikhail Shevtsov (SOI Vavilov)

Thank you for your attention