What is that thing on the wall?

Maybe an ancient musical instrument?
Young Greek holographer
an optimized LED illumination system for color reflection display holograms

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SPIE PHOTONICS-WEST
OPTO2013  San Francisco  (CA)
Hellenic Institute of Ολογραφία

- Established in Athens in 1987.
- Non-profit private organization
- Introduction & Promotion of Holography in Greece
- Scientific, Culture, Technology
- Non-academic holographic laboratory
- Documentation Center on holography
- Document and product authentication

Alkis LEMBESSION  Andreas SARAKINOS  Nikos ZERVOS
HoloCultura: our brief in 2009
Applied Holography in Cultural Heritage

- **‘Digital’ Holography:**
  - Filming Studio equipment
  - Transportable setup for image capturing
  - PC cluster and software for image processing

- **Analog Holography:**
  - Transportable laser camera
  - Portable film development studio
  - Support equipment and accessories

- **LED illumination:**
  - HoLoFoS - intelligent LED illumination
Institute of Electronic Structure & Laser
Foundation for Research & Technology - Hellas

leading center worldwide for research and development of innovative laser and optical technologies for the diagnostics and conservation of works of arts and antiquities

(105) published articles in scientific journals since 1996, (78) published conference proceedings since 1992, (1) book (2006) and (9) invited chapters in books

2013 McGroddy Prize (APS) on ‘Discovery of Metamaterials’
Digital Holographic Speckle Interferometry
Structural Diagnosis

Laser-Induced Breakdown Spectral Analysis

Multi-Spectral Imaging (IR-VIS-UV)
The biennial Keck Award by the Int’l Institute for Conservation of Historic and Artistic Works (IIC) for their common project “Laser rejuvenation of Caryatids opens to the public at the Acropolis Museum: A link between ancient and modern Greece” Vienna, Sep2012
‘Digital’ Holograms
2011: ‘Digital’ Holography

- **Z-Studio**:
  - 200sqm Athens City Center, Technical Univ. of Piraeus
  - Fully portable filming studio (LED lighting, Green-key etc.)
    - Small exhibition of digital holograms

- **Z-System**:
  - All image/video capturing geometries
    - **Z-Linear**: 3x150cm, custom-made electronics/software
      - **Z-Radial**: 120°, motorized Hollywood dolly on rails
      - **Z-Axial**: heavy-duty, fully programmable turntable
  - **Image processing**:
    - Workstations for image processing and rendering
    - Software adaptation for processing & previews
2011: Z-Studio

Z System
MULTI MODE PERSPECTIVE CAPTURE SYSTEM

HiH RnD
HELLENIC INSTITUTE OF HOLOGRAPHY

HiH
HELLENIC INSTITUTE OF HOLOGRAPHY
2011: Z-Studio

Target: multi-perspective capture system for stereoscopic 3D modelling, anaglyphs, lenticulars, 3D projection, holographic printing.

Holographic Map: Island of Kos (GEOLA)

Glasses-free autostereoscopic monitors (45’’)
Holographic Map: Island of Antiparos (ZEBRA IMAGING)
Analog Holograms
Holography in cultural heritage
2013: Analog Holography

- **Z-Lab**:
  - 100sqm basement Chalandri Athens
  - Fully transportable plate processing studio
  - Storage, R&D and finishing of images

- **Z$^{3}\text{RGB}}$-Camera**:
  - Fully transportable RGB laser camera
  - SS Lasers at 457nm, 532nm, 638nm
    - High-quality optics
    - Tested under **adverse conditions**
    - Stabilized equipment for object

- **Panchromatic Plates**:
  - SFERA/SLAVICH
  - ULTIMATE 04/08
Denisyuk-type holograms
The Problem

In theory, true-color Denisyuk holograms of high quality can be recorded in silver halide emulsions and subsequently be displayed reproducing life-like three-dimensional images, if certain prerequisites are fulfilled e.g.:

• Suitable selection of three or more laser wavelengths
• Panchromatic recording plates with mean grain size well below 10nm
• Optimized processing of the exposed plates
• Suitable recording geometry to eliminate dispersion
• Mechanical and thermal stability
• Optimized illumination of the color hologram in order to enhance depth reconstruction & color rendition and to minimize blur.
Cultural Artifacts

Hand-painted wooden egg

Hologram / Object
2011: Z3-Camera

Schematic setup

Holophos maximum relative luminance wavelengths:
- 450-465
- 520-535
- 620-630

Pan plates:
- [nm]: 350, 400, 450, 500, 550, 600, 650, 700, 750

Cobalt Samba™ 532nm 100 mW
Cobalt Twist™ 457 nm 50 mW
CrystaLaser 638 nm 70 mW

HelenaIC Institute of Holography

TE temperature
F/P beams monitoring
HU humidity
SP spatial filter
RGB RGB combiner
RG RG combiner
SH shutter
PR λ/2 plates
VD variable density
Recording True-Color Holograms

The combination of (3) wavelengths selected by HiH gives a gamut that includes yellow, purple, dark blue and violet and overlaps the Wintringham data.

An important consideration for this specific selection of wavelengths was the close matching to the emission characteristics of available power LEDs for the HoLoFoS hologram illuminating device.
Remote operation (Dec 2012)

Remote PC-driven operations, custom-built control software

LASER beam purity real-time monitoring by scanning interferometer
Preliminary Results (Oct 2011)

• Venetian Mask (cloth/fabric)
• St. Nicholas (silver/wood icon)
• Alabaster Wrestlers
ZZZyclops (Sep2012)

Industrial design
(awarded model-maker, ATHENS2004 Olympics torch)
Exposure Dark-Room
Chem Lab & Plate Development · Dark-Room
Ready for Action (Jan2013)

iLumogram printed by GEOLA size 3040cm

Z3 RGB CAMERA

BEAM RELAY MIRROR

PLATE & OBJECT

VIBRATION ISOLATOR

Z3 RGB Camera
The ‘Chios Epitaph’
an Optically Cloned Artifact

Running until Sep 2013
‘The Jeweled Net’
The Problem

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Replaying (illuminating) True-Color Holograms

TUNGSTEN halogen

Pure white target, tungsten halogen spotlight.
Spectrum Radiance Measurements
Replaying (illuminating) True-Color Holograms

TUNGSTEN halogen

A Tungsten Halogen source will produce considerable levels of scatter noise and chromatic blur. As the white point temperature of a tungsten halogen spotlight cannot be varied, it is very hard to make necessary color corrections to a replayed hologram with this kind of illuminating source.
An intelligent illuminant

digital control of color mixing,
WIFI communication,
DMX protocol (IP-address)
**COMMON RGB**

**MIXING PROFILE**
3 angularly displaced beams considerable angular separation

**CHARACTERISTICS**
Narrow bandwidth
High level of blur
Must be placed far from a hologram
May support intensity mixing
RGB-W version

MIXING PROFILE
3 angularly displaced beams
small angular separation

CHARACTERISTICS
Narrow bandwidth
Lower level of blur
Must be placed far
from a hologram
Smart control with intensity mixing
Trichroic Prism
(Dec2011)
Trichroic Prism

Mixing Profile
3 coaxial beams mixed with a dichroic cube

Characteristics
- Narrow bandwidth
- Minimal level of blur
- Can be placed close to a hologram
- Smart control with intensity mixing
An illuminating device that uses dichroic combiners to produce a coaxially mixed RGB beam. Single-chip red, green and blue LEDs with independent precision digital control of driving current for each color so as to achieve the desirable color gamut. The light emitted by each LED is collected by a small lens and steered through two dichroic combiners that mix the three beams into a coaxial exit beam.
v3 (Dichroic Filters)
Pure white target, *HoLoFoS* v.3 RGB illumination.
Spectrum and corresponding CIE point close to the CIE white point.
An illuminant fitted with a multi-chip RGBW LED with independent precision current control per channel and two biconvex lenses for shaping beam.

The white channel of the HoLoFoS v.4 is used to fill in the “gaps” of color shifting due to development and drying processes of a hologram. Similarly, it allows corrective illumination of digital holographic prints recorded by pulse lasers.
RGB-W with bi-convex lens
Pure white target, **HoLoFoS v.4** RGBonly (no W) illumination. Spectrum and corresponding CIE point close to the CIE white point.
Reflectance Radiance Spectrum Measurements from True-Color Holograms
‘Evzon 1912’
an Optically Cloned Artifact
Tungsten Halogen - Hologram

A large part of the tungsten halogen emission is lost due to absorption and scattering by the ‘Evron1912’ hologram
HoLoFoS v3 - Hologram
CONCLUSIONS

• The HoLoFoS v3 and HoLoFoS v4 hologram illuminating devices reconstruct deep single beam color holograms with enhanced contrast and saturated colors.

• The dominant wavelengths of the selected RGB LEDs can match commonly used sets of recording wavelengths and thus provide enhanced color reconstruction.

• Color balance can be easily adjusted by the precise control of the LEDs driving currents.

• The narrow band emissions of the LEDs and the small dimensions of the LED chips minimize the chromatic blur and the source size blur.

• Depth detail reconstruction is obtained at acceptable level thus enhancing the realistic viewing experience.
The HoLoFoS v4 radiance (as reflected from white target) is approx the same or better to the one from the 50W spot at the wavelengths 440, 532, 638 nm. The rest of the spectrum of the 50w spotlight does not contribute to image brilliance, but rather increases scatter and image blur, reduces contrast and de-saturates color.

<table>
<thead>
<tr>
<th></th>
<th>440nm</th>
<th>532nm</th>
<th>638nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>HoLoFoS v4 (RGB)</td>
<td>1.2E-2</td>
<td>6.5E-3</td>
<td>1.5E-2</td>
</tr>
<tr>
<td>HoLoFoS v4 (W)</td>
<td>8.0E-3</td>
<td>3.0E-3</td>
<td>1.5E-3</td>
</tr>
<tr>
<td>50 w Halogen</td>
<td>6.0E-3</td>
<td>1.4E-3</td>
<td>2.4E-2</td>
</tr>
</tbody>
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RADIANCE DISTRIBUTION (W/sr*sqm* nm) COMPARISON TABLE
The overall light intensity of the HoLoFoS v4 can be further increased (within manufacturer’s limits) but this introduces heating considerations.
Epilogue

“Beauty is in the Eye of the Beholder”
Thank you for your attention

www.hih.org.gr