The Use of Direct-Write Digital Holographic Printing for the Visualization of Perished Artworks and Historic Sites

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Established in Athens in 1987. Non-profit scientific and educational organization with its income derived by members’ contributions and services to third parties.

Mission:
Introducing and promoting Holography in Greece and abroad in all possible areas: cultural heritage, science, art, media and authentication.
A first program in cultural heritage for HiH (1995)

https://cordis.europa.eu/project/rcn/33449_en.html
The HiH HoloCultura program

In 2009, on the grounds of accelerated technological progress in various disciplines such as solid-state lasers, panchromatic emulsions, LED illumination, computer processing power, digital hologram printing etc., the Hellenic Institute of Holography set out its own ambitious HoloCultura program for the use of colour display holography in applications related to cultural heritage.

Analogue holography

- $\text{Z3}\text{RGB}$ Denisyuk-type colour holography system
- $\text{ZZZyclops}^{\text{TM}}$ (trans)portable laser camera
- $\text{HoLoFoS}^{\text{TM}}$ RGB illuminant
- $\text{OptoClones}^{\text{TM}}$
The HiH HoloCultura program

Results so far: OptoClones™ from four Museums in two countries.

Photo of OptoClone™

Photo of OptoClone™

Athens 2014

Thessaloniki Oct 2013
The HiH HoloCultura program

Results so far: OptoClones™ from four Museums in two countries.

St. Petersburg 2015

Moscow 2017
The HiH HoloCultura program

Direct -Write Digital Holographic printing

Acquisition and preparation of datasets for DWDH printing

• Acquisition of parallax-related images of natural scenes
  • Z-linear rail (modular up to 4.5m) with rotating head. Simple or re-centering mode. Computer controlled.
  • Z-axial rotating platform. Embedded controller.

• Software and workstations
  • Generation of virtual 3D C-G scenes
  • Image processing and preparation of parallax-related datasets for digital printing of holograms
Direct -Write Digital Holographic printing

Direct-write digital holographic printing (DWDH) is an AUTOSTEREOSCOPIC technique by which color reflection holograms or white-light transmission holograms of an object or a scene can be produced out of a series of suitable parallax-related images.

• The technique is well suited to the production of scaled-up or -down holographic images of objects or scenes allowing at the same time slight movements, animation, layering and multiple channels to be encoded.

• The series of perspective images can be digitally captured in video or photographs or be produced by rendering frames of a 3D scene with the aid of 3D computer graphics programs.

The Hellenic Institute of Holography (HiH) has been testing the process since 2009 producing suitable series of perspective images by using most of the available image capturing techniques and subsequently printing rendered data by Geola Digital (Lithuania), Zebra Imaging (USA), RabbitHoles (USA) for the visualization of artworks and historic sites.
Principles of DWDH printing

Schematic Courtesy of Geola Digital uab
Principles of DWDH printing

Classical digital holographic printer's objective: 1 - SLM; 2 - objective's waist; 3 - objective's FOV; 4 - photomaterial; 5 - reference beam; 6 - Fourier plain.

Optical holopixel's formation: 1 - SLM; 2 - objective's waist; 3 - viewing angles of particular SLM pixels; 4 - holopixel's recording place; 5 - holopixel; 6 - view from holopixel's window under different viewing angles.

Holopixels exposure onto photomaterial (horizontal parallax hologram): 1 - Rows of exposed holopixels; 2 - photomaterial; 3 photomaterial movement; 4 - reference beam.

(5) 0.4x0.4mm to 1.6x1.6mm

Schematics Courtesy of Geola Digital uab
Parallax-related images from 3d program
Parallax-related images from a real scene

Big FOV or Shift camera

Normal FOV
Needs printer-specific corrections

Normal FOV
Needs printer-specific corrections

recentering camera mode
Hologram of a *Paleolithic ceramic vase* found in the village of Dispilio (Kastoria, Greece), scanned and digitally *3D-modelled* by the National Technical Univ. of Athens (Photogrammetry Section).

The 3d model in *obj* format was imported in 3ds Max and a virtual camera was set up to move in linear mode rendering parallax pictures of the object in simple camera mode as described by Geola Digital uab instructions.

Digital parallax images preparation for by *HiH*. Printed by *Geola Digital*, 20x25cm portrait, holopixel size 0.8 mm.
A hologram of a ceramic vase (original video filmed on rotational turntable) in a multi-layered composition (Picture in Picture) by HiH demonstrating various depth planes. The original video footage was transformed into a jpg pictures sequence and used as surface material for a plane in a 3ds Max scene. A computer model of a distorted torus with a glossy green surface material was also introduced in the scene. A virtual camera was set up to render the parallax images while the software was advancing the jpg sequence surface material of the plane exposing geometrically corrected sequential perspective images of the vase to the camera.

Digital parallax images preparation by HiH. Printed by Geola Digital, 20x25cm portrait, holopixel size 0.8 mm.
This trial digital hologram is aiming to demonstrate the use of already existing and freely available digital content in a low-resolution 3D model available for public common application depicting a well-known Greek object of cultural interest. The original model in obj format was imported into an E-ON Vue software 3d scene. A background plane with neutral lighting was introduced to enhance the 3D impression of the statue in the final hologram without any further additions to this iconic statue of world cultural heritage.

Digital parallax images preparation by HiH. Printed by Geola Digital (LI) and RabbitHoles (USA), 35x50cm portrait, holopixel size 0.8 mm.
A trial digital hologram aiming to demonstrate the use of original filming footage of a relatively larger object of cultural interest by using the portable traveling-camera setup (Z_Linear) of HiH and mixing of footage with CG. A cast statue of a horse of 1m in height and of approx. 50x50cm in footprint was filmed with the camera moving in re-centering mode under suitable white LED lighting. The horse was filmed in digital video with a green screen background which was removed by color keying. The video sequence was exported as a PNG sequence with transparency and used as surface material for a plane in an E-On Vue 3d software scene. Animated logos were added to the rendered views by compositing in AfterFX. Digital parallax images by HiH.

Printed by Geola Digital, 60x48cm landscape, holopixel size 0.8 mm
'Diomedes Horse' by HiH (2011)
A digital 3D model in obj format of the iconic Memorial of monumental size (sculpture by G. Zongolopoulos) available from on-site laser scanning of the construction by the Photogrammetry Section of the National Metsoveion Polytechnic (Prof. G. Georgopoulos) was digitally placed on a virtual mountain rock in E-On Vue software 3d scene. This majestic monument of Zallongo, Western Greece was created between 1954-1960 and consists of 4500 pieces of white stone based on a beton skeleton, of size 15m in height and 18m in length, visible from a distance of 25km. An atmosphere with clouds and a blue sky was also added to enhance the image.

Digital parallax images preparation by HiH. Printed by Geola Digital, 35x50cm portrait, holopixel size 0.8 mm. Comparative print: RabbitHoles.
‘St. Nicholas Kronstadt Naval Cathedral’
‘St. Nicholas Kronstadt Naval Cathedral’ by HiH (2015)

A digital holographic print depicting an aerial 3D-view of the fully restored (2013) Naval Cathedral in the city of St. Petersburg. The Naval cathedral of Saint Nicholas in Kronstadt is the main church of the Russian Navy and dedicated to all fallen seamen. The building was video filmed by a drone flying in a circular path Commissioned by ITMO University. This hologram was created in multiple versions (variant logos: ITMO, HiH, MirNauki) and sizes (larger format 64x48cm-2 copies, smaller format 42x32cm). The original larger size hologram (framed) was the official donation of ITMO Univ. to Patriarch Kyrill of Russia on his birthday (2016).

Concept and execution: ITMO University. Original footage filmed in June 2014 by A.G. Karmanov, N.G. Anisimova. Digital parallax images preparation by HiH. Printed by Geola Digital, holopixel size 0.8mm.
‘St. Alexander Nevsky Lavra’ in St. Petersburg
An impressive digital holographic print of an aerial view of Saint Alexander Nevsky Lavra, founded by Peter I of Russia in 1710 at the eastern end of the Nevsky Prospekt in Saint Petersburg, the supposed site of the Neva Battle in 1240. Commissioned by MirNauki (an affiliate of ITMO Univ. and the City of SPb). Arial drone footage by GeoScan on basis of HiH instructions. Part of the original footage totaling 700 frames was selected and digitally stabilized. This part was interpolated to 2135 frames then exported as a jpg image sequence. This sequence was assigned as the surface material of a plane in a 3dsMax scene.

Printed by Geola Digital in 2 copies (64x48cm) for use by local customer and one copy (42x32cm landscape) for HiH demo collection. Holopixel size 0.8 mm. Digital parallax images preparation by HiH.
‘St. Alexander Nevsky Lavra’ in St. Petersburg
Metropolite St. Petersburg Varsonoviy
"St. Alexander Nevsky Lavra in St. Petersburg" by HiH (2016)

3d model created by Geoscan by 2d-to-3d conversion of aerial footage. **Loss of detail** especially in foliage.

The DWDH printed hologram from the original aerial footage.
‘The Temple of Bel’ in Palmyra (Syria)

The Temple of Bel in Palmyra, Syria, prior to being destroyed by ISIS forces in 2015

Photo: MarekPL
‘The Temple of Bel’ in Palmyra (Syria) as it stands today (2018)

Photo: Maher Al Mounes / AFP/Getty Images
A digital holographic print depicting a 3D view of the Temple of Bel in Palmyra, Syria, as it was before it was destroyed in August 2015. Hundreds of photos taken by tourists visiting the Temple of Bel site in the past years were submitted to Arc/k Project (http://arck-project.org/) to produce this crowd-sourced 3D model. The sequence of parallax views was screen-captured from the online model created by the Arc/k Project as presented in the Sketchfab web site (https://sketchfab.com/models/7a82cb38ebf042b28735339379d911e5). The captured sequence was interpolated to 2135 frames.

An experimental holographic print to explore the possible uses of holography in the visualization and preservation of historical sites by crowd-sourced input. Printed by Geola Digital, size 30x40 cm landscape, holopixel size 0.8 mm. Digital parallax images preparation for DWDH by HiH.
‘The Faberge Coronation Egg’ (Filming 2015)
On exclusive license to HiH to video-film in-situ the most famous and recognizable of the Imperial Faberge Eggs, the 'Coronation Egg', for the first time in high-resolution and under controlled parameters. This filming took place in the evening of April 30, 2015 by Elena Bobritskaya of ITMO University with the assistance of Museum Curator Alexey Pomigaloff on the instructions and supervision of Andreas Sarakinos using equipment brought in the Fabergé Museum by HiH. Excerpt from this 360o footage was digitally processed and rendered by A.Sarakinos using the facilities of HiH in Athens, Greece and was used by GEOLA DIGITAL uab in Vilnius, Lithuania as in-kind sponsorship of the event for the origination of a master hologram on photo-resist. The resulting master was then used by HOLOGRATE in St. Petersburg (also sponsor of ISDH2015) to emboss a limited number of 200 pressure-sensitive labels in transparent high-refractive material for manual application. Size approx. 8x5 cm portrait, 0.8 mm holopixel size.
the Tsushima Battle (1905)
Maritime Museum St. Petersburg

РУССКО-ЯПОНСКАЯ ВОЙНА 1904–1905 гг.
ЦУСИМСКОЕ СРАЖЕНИЕ.

Russian-Japanese War
1904–1905
The Tsushima battle
Maritime Museum St. Petersburg
Maritime Museum St. Petersburg
AURORA Museum St. Petersburg
‘Ship replicas of the Tsushima battle’ from the Maritime Museum St. Petersburg (HiH 2018)
A series of 8 ship replicas ranging in size from 50 cm to 2.50 meters approximately were digitally captured with a linearly travelling camera moving in a quasi recentering mode with a green screen background. These are replicas of the Russian navy battleships that took part in the Battle of Tsushima in 1905. The shooting was done in collaboration with ITMO University in June 2016. Six of these datasets were used in 2016 for lenticular printing backlit 3d posters that are in display inside the Aurora battleship Museum in St. Petersburg, Russia. The files were processed in 2018 in 3ds max and AfterFX to produce the corrected datasets for DWDH printing.

Printed by Geola Digital, size 17x35 cm landscape each, holopixel size 0.8 mm. Digital parallax images acquisition supervision and preparation for lenticular and DWDH printing by HiH
Conclusions

• The DWDH printing process is capable of producing holographic prints from a variety of parallax datasets acquired with digital video, digital photos or computer generated.

• Drone acquired images can be used for the holographic visualization of large buildings and historical sites.

• Crowd-sourced images can be used to construct 3d models of artworks or sites and then to be DWDH printed.

• The ease of combining footage of physical objects with computer generated 3d models is an appreciated option.

• It is of great significance that the video or photographically captured perspective views of a real object or scene, as processed by Geola Digital uab, may result in holograms which recreate 3d images with details resolution far better than those of a 3D model produced from the 2D-to-3D conversion of the same set of perspective views, especially foliage.

• We hope that the presented DWDH printed holograms of various artworks and historic sites, the various methods used for capturing perspective views and the underlying printing processes can be used as a reference tool for eventual use of digitally printed holograms in cultural heritage preservation.
Thank you,

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