Digital Motion Hologram

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Holography:

A technique which enables three-dimensional images (**holograms**) to be made. It involves the use of a laser, interference, diffraction, light intensity recording and suitable illumination of the recording.

DIGITAL HOLOGRAPHY IS A NATURAL BORN AR
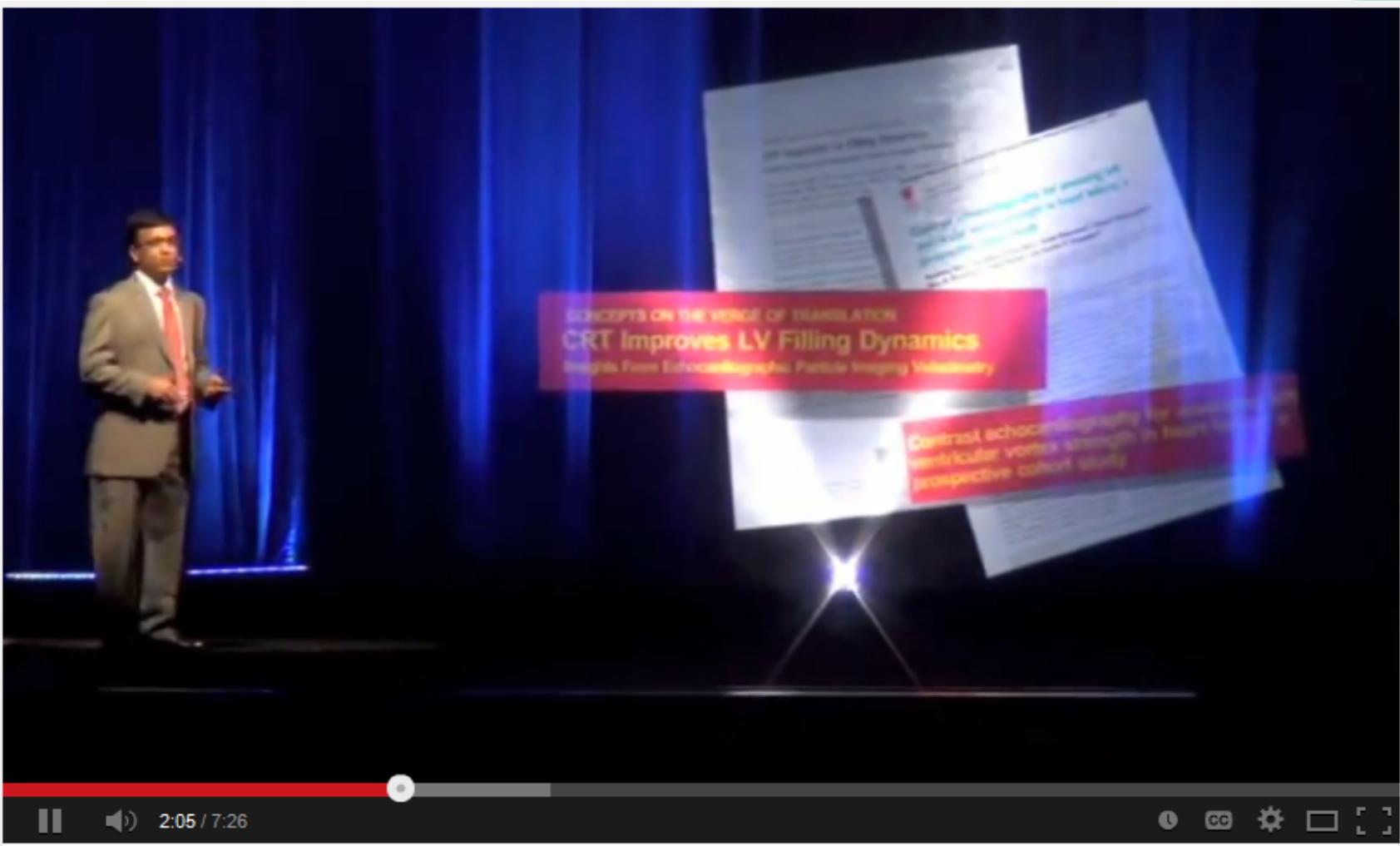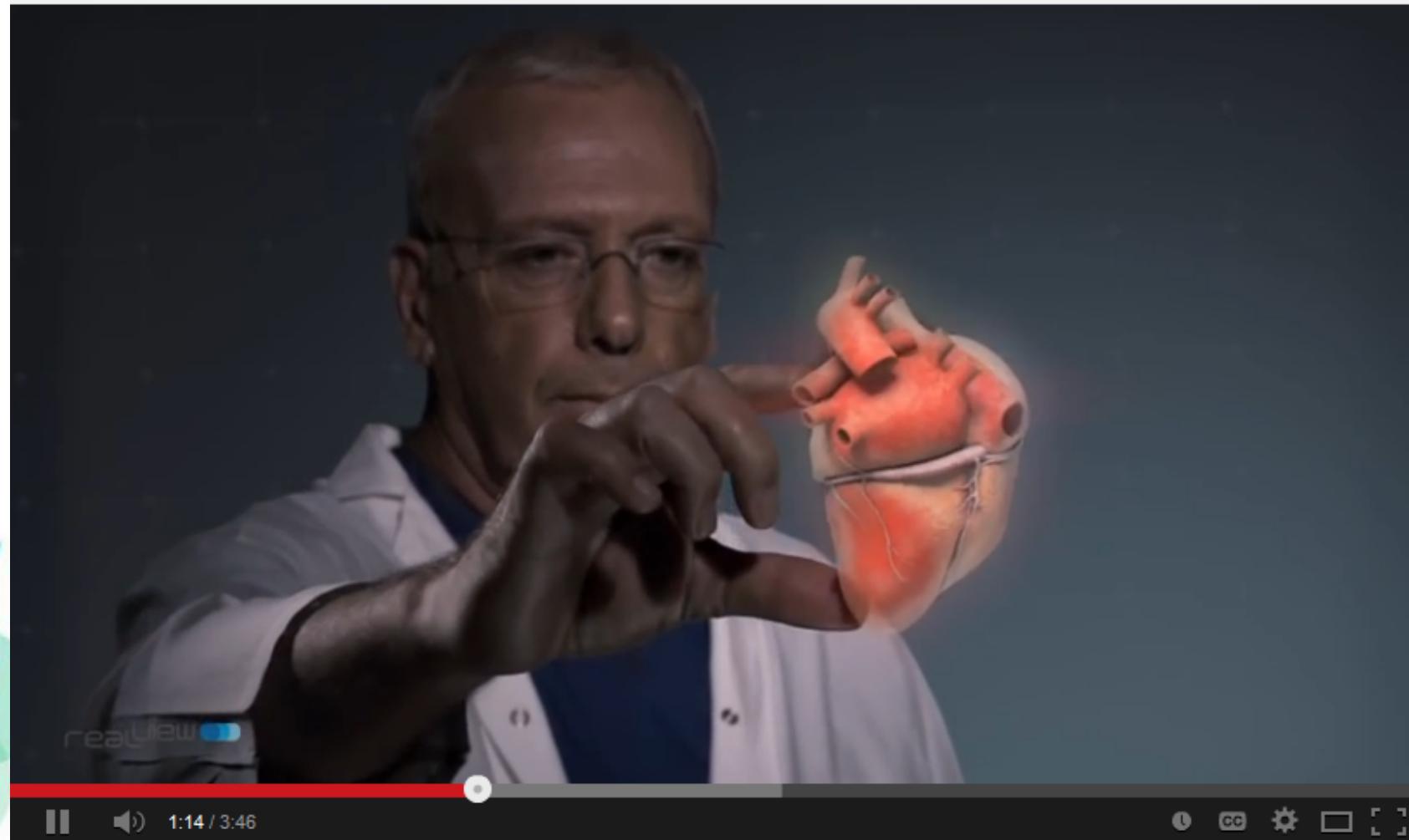
Terms and Definitions

- Digital Hologram
  - The data calculated by a computer applying a math modeling about the diffraction pattern of light

- Digital Motion Hologram
  - The digital hologram with a sequence of (translate, rotate, scale parameters) with respect to given data

- Hologram Fringe Pattern
  - Pattern of a digital hologram

- Computer Generated Hologram
  - Digital Hologram calculated by Computer

- Spatial Light Modulator(SLM)
  - An object that displays digital hologram through spatially varying modulation on a beam of light.

Analog Holography - Concept

Recording Hologram

laser♪

Mirror♪

Object♪　Object Beam♪　Hologram♪

Hologram (fringe pattern)

Reconstruction 3D Object

laser♪

Mirror♪　Reference Beam♪

Reconstructed 3D Object♪　Hologram♪

Observer♪

http://www.ultimate-holography.com♪

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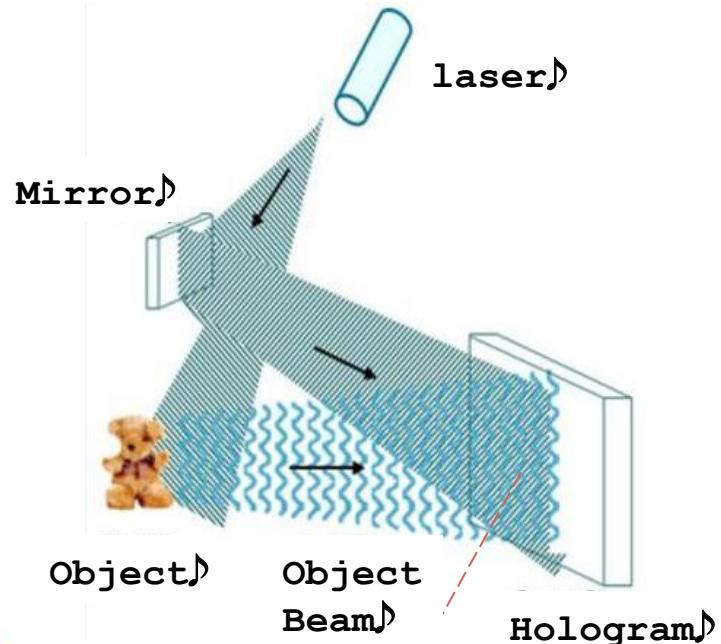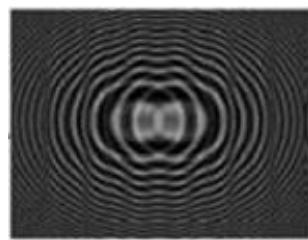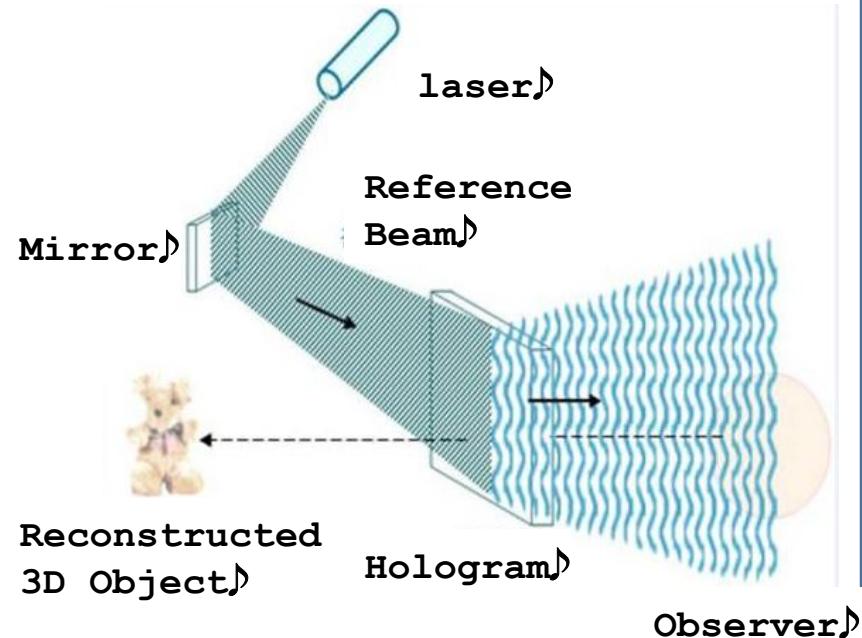
Analog Holography - Methods

	Transmission hologram	Reflection hologram
Reconstruction Method	Light source / hologram	Light source / hologram
Generation Principles	Mirror ♪ / Laser ♪ / 레이저 광원 / 거울 / 피사체 / Object♪ / 물체파 / 거울 / 렌즈 / Lens ♪ / 렌즈 / 기준파 / ref ♪ beam♪ / obj.♪ beam♪ / 렌즈 / Holography sensitive plate♪	Mirror ♪ / Laser ♪ / 레이저 광원 / 거울 / 거울 / Object♪ / 거울 / Lens ♪ / 렌즈 / 기준파 / ref ♪ beam♪ / 물체파 / obj ♪ beam♪ / 렌즈 / Holography sensitive plate♪
Exposure	Exposing film with the object and reference beams in the same direction	Exposing film with the object and reference beams in opposite directions
Result	Clear and bright color	Better volume sense
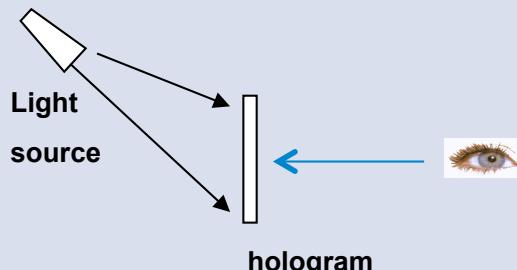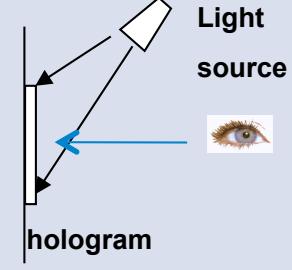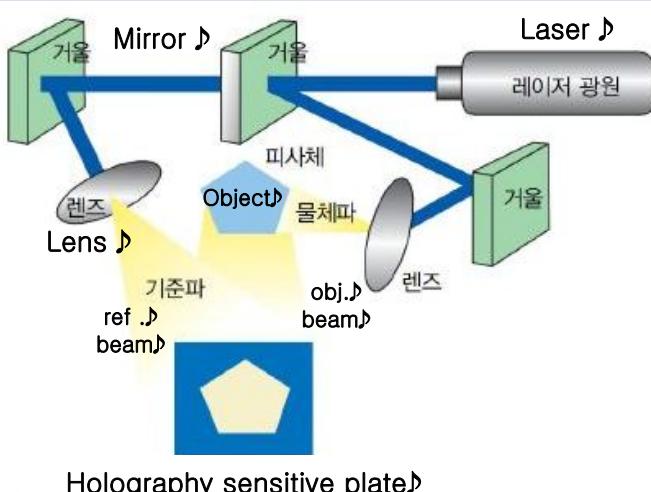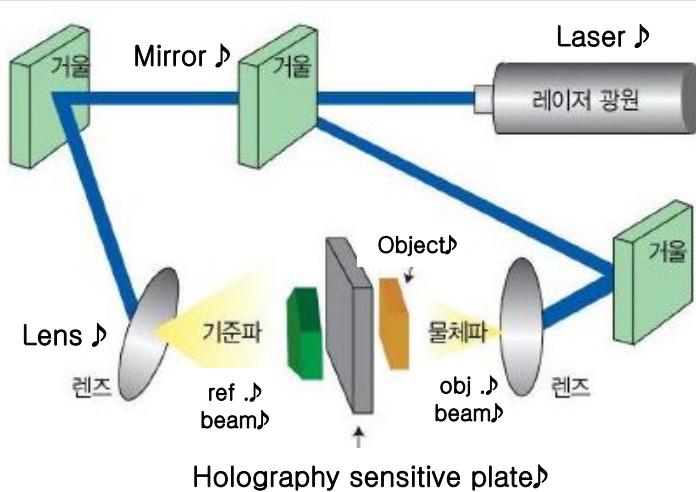
Digital Holography - Concept

| 3D Image Acquisition | 3D Model Data | CGH generation | Hologram data | Reconstruction 3D Object from Hologram |

Digital Processing

Digital Holography - Methods

Inputs (left column):
- Depth image
- Stereo image
- Integral imaging
- multi-view image
- 2D/3D conversion
- Virtual 3D object

3D modeling data (Point cloud, 3D Mesh)

CGH (**Computer Generated Hologram**) **generation algorithm**

Mathematical Modeling for Diffraction and interference of light

Fringe data (2k,4k,8k)

1) Optical reconstruction (using Spatial Light Modulator)

2) Numerical reconstruction (using CGH reconstruction algorithm)

3) Hologram film recording(Printing)

Analog Hologram Reconstruction

$$\Phi(x,y,z) = \frac{1}{i\lambda} \iint \Phi'(\rho,\sigma,0) E_R(\rho,\sigma) \frac{e^{ikr}}{r}\, d\rho d\sigma$$

$E_R(\rho,\sigma)$ $\phi'(\rho,\sigma)$ Real Image point

Hologram

Included Amplitude and Phase Information

10♪

Digital Holographic(DH) File Format

TTAK.KO-10.0629: Data Format for Digital Hologram

	Hologram generate parameter	Bit	Definition
3D Modeling	point cloud	1	Point cloud model
	angular spectrum		Polygon mesh model
Reference Beam	intensity	8	Intensity of reference wave
	Incident angle, Φ	16	Incidence of reference wave(˚)
	wave length(color), λ	16	Wave length of reference wave(nm)
Transfer Function	pixel pitch, p	16	Pixel pitch(um)
	propagation distance, d	16	Distance of object and hologram
	resolution, M × N	32	Hologram resolution
	SLM Type	2	SLM Type : LCD/LCoS, DMD, AOM)
	Fringe Type	2	Fringe data Type :amplitude-only, phase-only, interference
	Object Size	16	Size of 3d object
	View angle	16	View angle of reconstruction image
	Spatial frequency	16	Spatial frequency
	Hologram file depth	16	Hologram file depth
Hologram Type	Hologram rtype 1	1	Hologram regeneration Type 1 : Transmission/Reflection
	Hologram rtype 2	1	Hologram regeneration Type 1 : On-axiis/off-axis
Optical Parameter	Lens para.	32	Lens parameter : focal length, diameter
	Prism x-y	32	Prism x,y information
	gamma	16	Gamma function value
	x-y shift	32	Shift x-y axis

Digital Hologram Data File Format

TTAK.KO-10.0629: Data Format for Digital Hologram

Hologram Header Info	Amplitude Data	Phase Data

CGH Generation Algorithm	Reference Light Source Info	SLM Parameters	Hologram Type	Optical Parameters

LCD/LCoS♪

DMD♪

AOM♪

Transmission

Reflection
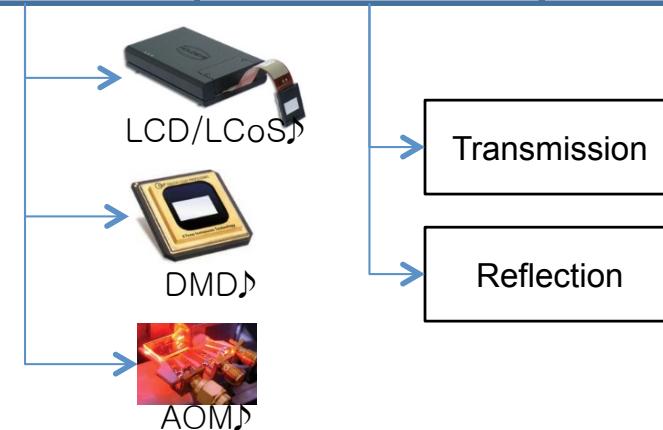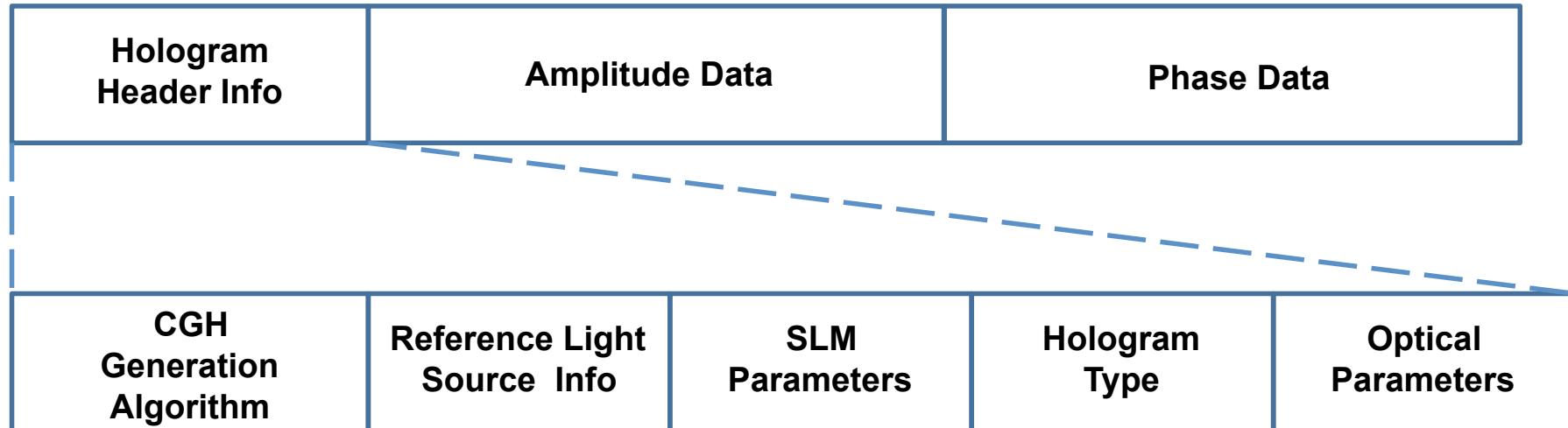
Data Format for Digital Motion Hologram

Processing step of
Digital Hologram Data
Processing Step
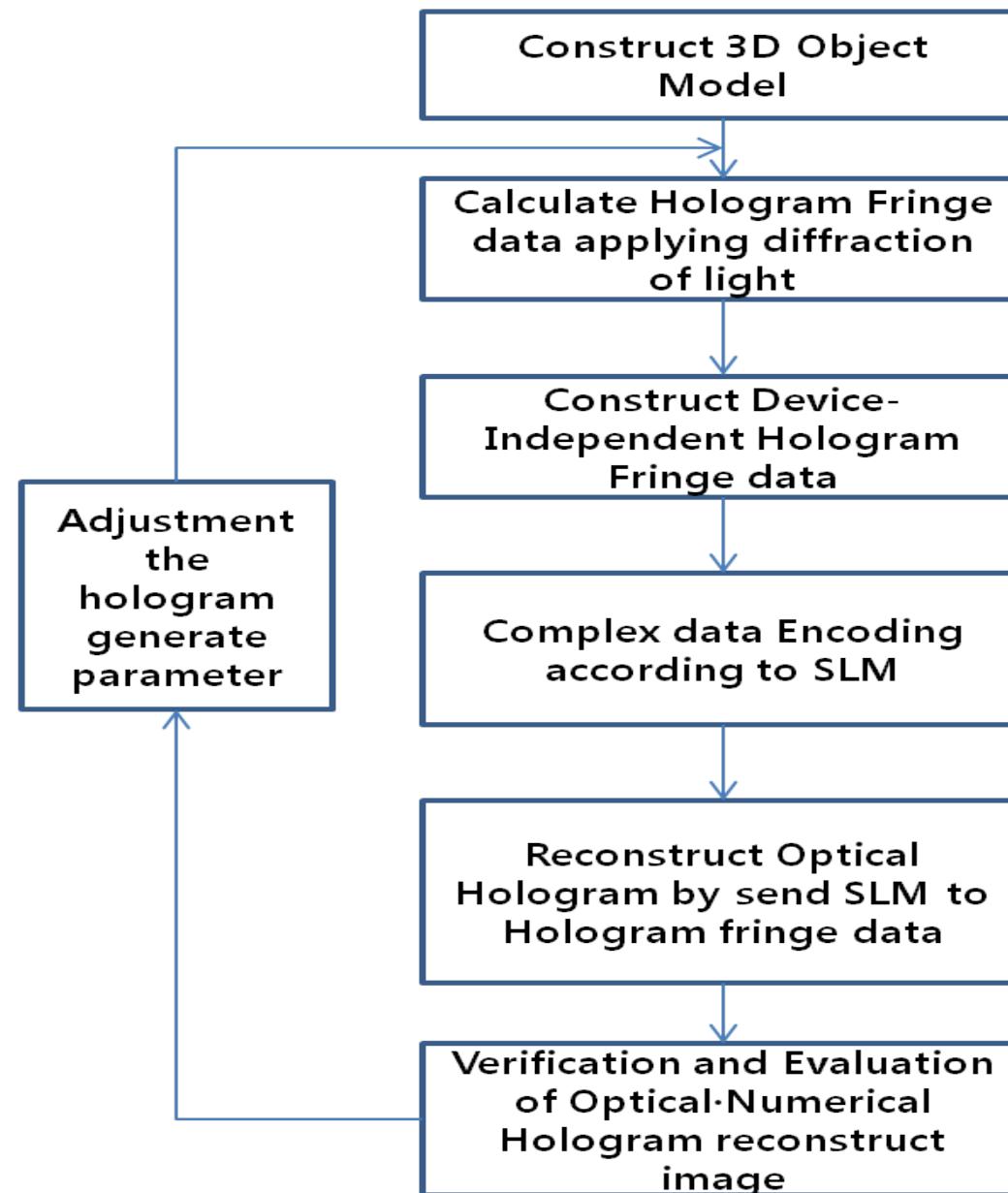
Digital Motion Hologram Generation Parameters

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	x-y shift	32	Shift x-y axis
Transfer /Rotate	Center_point-x	32	Center x coordinate of hologram
	Center_point-y	32	Center y coordinate of hologram
	Center_point-z	32	Center z coordinate of hologram
Scale	Scale_x, Scale_y	16	Scale m about hologram x,y coordination
	Scale_z	16	Scale m^2 about hologram x,y coordination
		415	

SLM : Spatial Light Modulator　　　　LCD : Liquid Crystal Diode
LCoS : Liquid Crystal on Silicon　　　DMD : Digital Micro-mirror Device
AOM : Acousto-Optical Modulator

· Add Transfer/Rotate, Scale parameter information to obtain multiple Hologram

Digital Motion Holographic(DMH) File Format

	Hologram generate parameter	Bit	Definition
3D Modeling	point cloud	1	Point cloud model
	angular spectrum		Polygon mesh model
Reference Beam	intensity	8	Intensity of reference wave
	Incident angle, Φ	16	Incidence of reference wave(°)
	wave length(color), λ	16	Wave length of reference wave(nm)
Transfer Function	pixel pitch, p	16	Pixel pitch(um)
	propagation distance, d	16	Distance of object and hologram
	resolution, M × N	32	Hologram resolution
	SLM Type	2	SLM Type : LCD/LCoS, DMD, AOM)
	Fringe Type	2	Fringe data Type :amplitude-only, phase-only, interference
	Object Size	16	Size of 3d object
	View angle	16	View angle of reconstruction image
	Spatial frequency	16	Spatial frequency
	Hologram file depth	16	Hologram file depth
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Optical Parameter	Lens para.	32	Lens parameter : focal length, diameter
	Prism x-y	32	Prism x,y information
	gamma	16	Gamma function value
	x-y shift	32	Shift x-y axis

Digital Motion Hologram Data Stream Structure

HSB	Header	SA	AType	ABitLength	ADataStream	SP	PType	PBitLength	PDataStream

415bits

Modeling	ReferenceBeam	TransferFunction	HoloType	OpticPara	Translate · RotatePara	ScalePara

· Hologram data stream include
Device-Independent data.
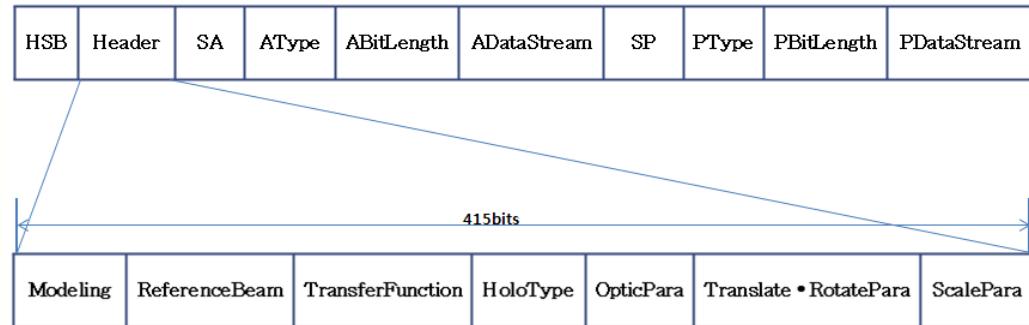
Information for stream	Definition
HSB	Start Bit of the Hologram fringe data
Header	The header information including Hologram generate parameter
SA	The amplitude of the hologram (or the real part) on the data start bit string
AType	The amplitude type data of the hologram
ABitLength	The bit size of the amplitude of the hologram data stream
AD ataStream	The data stream of the hologram amplitude
SP	The start bit string on the hologram phase data(or imagenaries parts)
PType	The phase type data of the hologram
PBitLength	The bit size of the phase data stream on the hologram
PDataStream	The phase data stream of the hologram
Modeling	The data generation method for 3D modeling(point cloud model / polygon mesh models)
ReferenceBeam	The information of ReferenceBeam
TransferFunction	Hologram fringe pattern data generation parameter
HoloType	Hologram regeneration Type
OpticParas	Optical value (etc. Lens parameter)
TranslateRotatePara	Transfer/Rotate parameter of hologram
ScalePara	Scale parameter of hologram

User Requirements of Digital Holographic Content

| |
|---|
| Display DMH Content's output result in new window(Mesh data, Hologram data, Reconstruction image data) |
| Provide Motion Sequence based on Multiple DMH Content |
| Provide Save & Load, Parameter setting window |
| Provide intuitive use about DMH Content |
| Provide Compare, Contrast Document & Program code |

# Authoring of Digital Motion Holographic Content

· Include Input data load/transfer, set parameter, Output data Check/save, Project manage

· Save/Exchange apply in DMH data format (*.dhc)

· Production processing content are managed by each project

· Permission is limited as authority

▸ Authoring of Digital Motion Holographic Content

· Beom-Ryeol Lee, File Format for Holographic Content, 2012. 05. 15
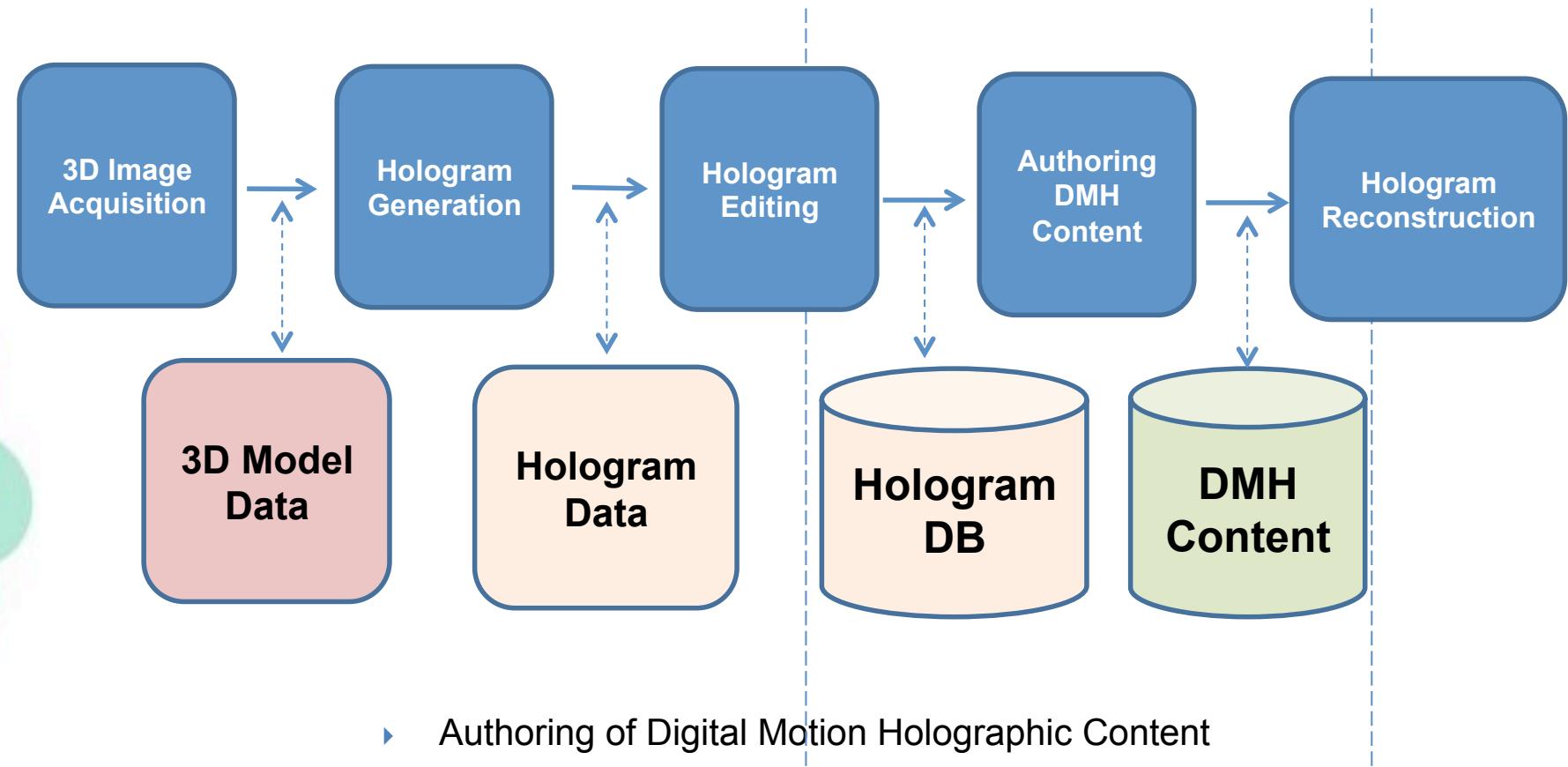
Editing of Digital Holographic Content

Virtual/Real Object → **Optical 3D Info Acquisition** / **Image Sequence** → **CGH Generation** → **DH Content (Fringe Pattern)** → **Editing** → **Optical Reconstruction (Electro Hologram Display)** / **Numerical Reconstruction (CG based Rendering)**

Fringe pattern DB

3D Image Acquisition
- Depth Map
- RGB Color Map
- Normal Map

Computer Generated Hologram (Fringe Pattern)

Preview/Synthesis /Cut/Annexation /Sewing

CG/ Optical Reconstruction

Management of Digital Motion Holographic Content
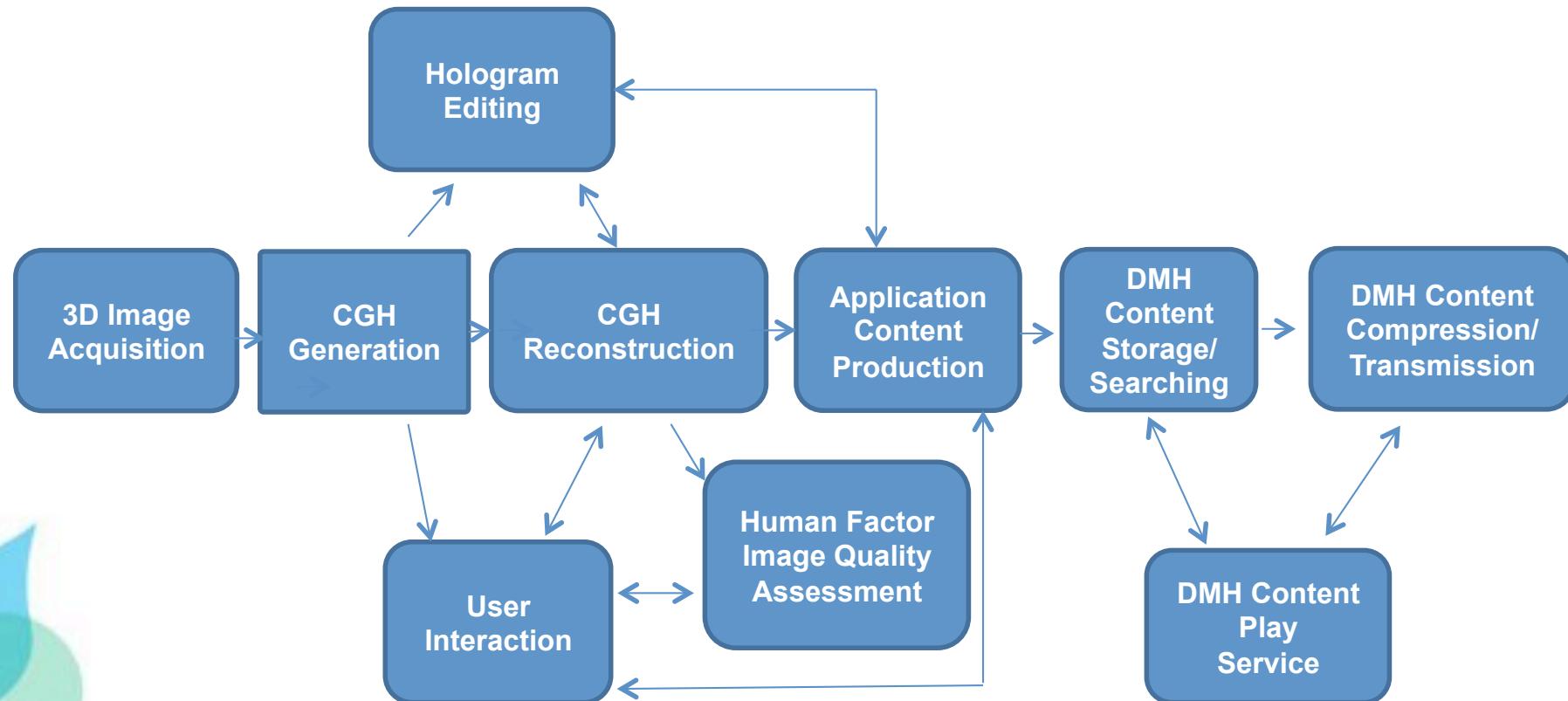
Applications of Digital Holography

Digital Contents

Scene Compositing / Simulation

Environment Sensor

Lighting condition Description

Fringe Patterns

Rendering

Stereoscopic Image Gen.

Multi-view Gen.

Hologram Reconstruction

Display Devices

Display

3D TV

See-through HMD

Spatial Mapper

Spatial Mapping Description

Event Mapper

Event Mapping Description

Spatial Registration for Digital Hologram

Matching Between Real and Virtual Environment

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Concluding Remarks

- **Proposals**
  - Digital Motion Hologram Data Format
  - Spatial Registration Description
    - Device independent Issues
    - Device dependent Issues especially for Digital Hologram
  - Matching Environments
    - Consider various conditions (like lights)

- **Realization**
  - Digital Motion Hologram-based HMD can overcome a restriction of current device

Thank you for attention!