

# Light ID and HMD-AR Based Interactive Exhibition Design for Jeonju Hanok Village Immersive 3D View

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## 전주 한옥마을의 실감 3D View를 위한 Light ID 및 HMD-AR 기반 인터랙티브 전시 설계

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**Abstract** The digital convergence looking for new ways to engage visitors by superimposing virtual content on projection over the real world captured media contents. This paper propose the Light ID based interactive 3D immersive exhibition things view using HMD AR technology. This approach does not required to add any additional infrastructure to be built-in to enable service and uses the installed Lighting or displays devices in the exhibit area. In this approach, the Light ID can be used as a Location Identifier and communication medium to access the content unlike the QR Tag which supports provide the download information through web interface. This utilize the advantages of camera based optical wireless communication (OWC) to receive the media content on smart device to deliver immersive 3D content visualization using AR. The proposed exhibition method is emulated on GALAXY S8 smart phone and the visual performance is evaluated for Jeonju Hanok Village. The experimental results shows that the proposed method can give immersive 3D view for exhibit things in real-time.

**요 약** 최근 디지털 컨버전스는 현실세계를 기반으로 만들어진 미디어 콘텐츠에 가상 콘텐츠를 투영시켜 사용자에게 새로운 경험을 제공할 수 있도록 발전하고 있다. 이에 본 논문에서는 HMD AR 기술을 이용한 Light ID 및 HMD-AR 기반 인터랙티브 전시를 제안하였다. 이 접근법은 현재 사용되고 있는 전시물에 추가적인 인프라를 설치할 필요 없이 기존 사용되고 있는 조명 또는 디스플레이를 사용할 수 있다. 또한 Light ID는 웹 콘텐츠로의 접근을 위해서만 사용되는 QR 태그와 달리 위치 인식을 위한 식별자 및 통신 매체로도 사용될 수 있는데, 이는 카메라를 기반으로 한 광 무선 통신 (OWC)의 장점을 활용하여 스마트 장치에서 미디어 콘텐츠에 대한 ID를 수신하고 AR형태로 실감 3D 콘텐츠를 시각화하여 제공한다. 본 논문에서는 안드로이드 스마트폰을 사용하여 제안한 설계 기법에 대해 전주 한옥 마을을 타겟으로 Light ID 기반 광무선통신 기술을 활용한 실감 3D View 제공 기술을 구현하고 테스트를 수행하였으며, 실험 결과 제안한 기법을 통해 전시물에 관한 실시간 몰입형 3D 뷰를 제공할 수 있음을 확인하였다.

**Key Words :** HMD-AR, Immersive 3D View, Interactive Exhibition, Light ID, Optical wireless Communication

### 1. Introduction

The technology advancement on display technology and connectivity improvement on internet of things (IoT) enhances the digital exhibition technology to collect and manages exhibits information in digital forms and provides the exhibit thin

gs information to visitors through internet. This helps visitor to get to know the exhibit things information through web interface as they need to know but still this won't helps engage the visitors more lively presence their focus on exhibition moment so the exhibition system design needs to highly

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considered the key factors like usability, availability, interactivity, attention, and immersion.

The exhibit things interactions are enabled through RFID Tag, QR-Code Tag to access the exhibits things specific information to view on smart devices through wireless network [1] and limits the access by downloading content to view instead of live view. The radio frequency (RF) wireless communication edging towards frequency saturation and bandwidth is divided to multiple at exhibits conditions [2]. To overcome RF limitations, this paper use the Light ID as a Tag to do user interaction through lighting and display devices used in exhibitional environment infrastructure.

The decisive development on computer vision technology enables people to reconstruct reality to change thoughts on the limits of perceived human visual experience helps to overcome the limitations through modern digital exhibition. Augmented Reality (AR) breaking down the boundaries between the virtual and real worlds and helped peoples perceive the immersive visual experience in natural environment by overlays virtual information on the peoples view of the real world in real time.

The Head Mounted Display (HMD) - AR is a promising technology allow the user to see virtual content superimposed over the visitors surrounding area with rich visual experience wherever they are located as a wearable AR computing system [3]. This helps exhibition system design with immersive rich exhibit things content delivery with high visitor engagement factors.

This paper use the Light ID based user interaction through Lighting device and display on exhibitional environment infrastructure. The proposed idea is emulated on smart phone with HMD-AR device at Jeonju Hanok Village and presented the implementation analysis on this paper.

## 2. Related Work

The scientificity, availability, usability, interesting, immersion and interactivity are the key factors to be highly considered, when building digital exhibits design [4]. The RFID or QR-Code Tag used to scan the code and the act of scanning connects with exact location in the world and downloaded the augmented information that can be seen from the position using smart devices [1]. The color QR codes are used to increase the data capacity and scanning speed since the standard QR code can able to embed limited data only [5].

The lighting device based Light ID Tag is an replacement technology for RFID ID and QR Code to interact with exhibits things using smart devices. The Light ID uses the lighting / display devices as a transmitter by controlling light illumination level [2] and smart devices camera as a receiver is called optical camera communication (OCC) as shown in Fig. 1 which is standardization is active in IEEE802.15.7m Task group with different PHY modes [2],[6~8].



Fig. 1. Light ID and OCC Technology

The proposed Light ID based exhibits things interaction does not required any additional infrastructure to installed like RFID or QR Code based user interaction approach.

The multi-view surface matching approach intr

duced to fully automated the process of constructing a digital three-dimensional (3D) model of a real-world objects and environment from a set of 3D views of a scene obtained from different view points [9] as shown in Fig. 2.



Fig. 2. 3D View Modeling[1]

The vanishing point constraints on the 2D outlines overlaid on photos from different view points used to reconstruct 3D geometry for 3D model and automatically computed by combining the 2D interaction with the multi-view geometric information [10].

The resolution, Field-of-View (FoV), depth cues, latency are the visual properties to be considered on HMD-AR system design to provide human visual capability comparable virtual information registered in 3D view in real-time[11]. The novel user interaction techniques for a combined handheld display (HDD) touch screen for interacting with the content and the HMD for viewing AR content [3].

The optical see-through HMD utilizes the multi-plane display technology for AR applications which solves accommodation-vergence conflicts on the state-of-the-art 3D HMD-AR visual rendering. The novel user interaction techniques for a combined handheld displays(HDD) touch screen for interacting with the content and the HMD for viewing AR content [12].

### 3. Interactive Exhibition Technology

The next generation exhibition technology has

considered new features like exhibits things information digitalization, exhibits virtualization, information sharing through internet, information offering intelligentize by interaction and exhibiting diversification. The digitization creates vibrant changes exhibition technology and create new research opportunities on design, digital virtual exhibit content creation, and content delivery on network.

The rapid development on internet technologies activates visitors interactive content delivery on web through network. At present exhibit things interactions through RFID or QR-Code Tag to extract the location information through web interface and audio/video media contents are played on player on the web. The RFID or QR-Code Tag based user interaction through scanning of the exhibit things code and act of scanning connects the exact location in the place where visitors localized and based on that location information the exhibits things augmented information can be seen on visitors smart device through WiFi connectivity. The Tags are used only to localize the location information and need additional network connectivity. This is shared network connectivity so the quality degradation or delay on delivery is perceived through content when multiple visitors try to access the same exhibits things content at the same time and need to be added additional infrastructure installation to enable visitors interactions.

To overcome these issues, this paper proposes the Light ID Tag based interactive exhibition approach where uses the lighting things and display as a communication medium as well location information identifier. This does not require to install additional infrastructure and multiple visitor access the same exhibit things content with same data rate.

### 4. HMD-AR 3D View

HMD-AR display technology that greatly enhances

ces users perception by overlays computer-generated virtual information on the user's view of the real world information in real time. One particularly promising application area is wearable AR, where AR systems allow the user to see virtual content superimposed over their surrounding environment visions wherever they are see through virtual rendered contents on a HMD as shown in Fig. 3.

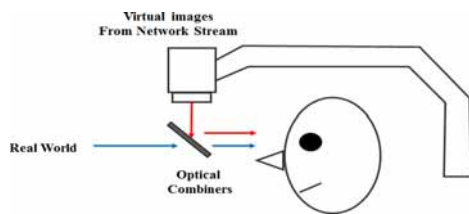


Fig. 3. HMD AR View

The virtual content received through network or local host processor and superimposed on the camera captured visual frame then rendered on the screen. The Virtual AR content flow shown in Fig. 4.

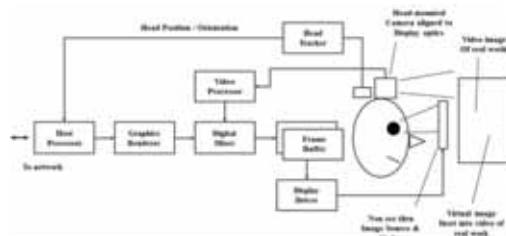


Fig. 4. HMD AR Virtual Content Flow

### 5. Light ID based Interactive Exhibits Using HMD-AR

This paper propose Light ID based exhibit things interactions using HMD-AR to design a visitor fascinated immersive 3D rendering. The Light ID act as location identifier as well as wireless communication transmitter using visible light communi

cation (VLC) method and the HMD-AR camera with smart device baseband processor act as an receiver to decode 3D AR virtual media content on smart device. The lighting or display devices used as Light ID. The light ID based interactive exhibits block diagram is shown in Fig 5. The exhibit things 3D virtual content is stored in Cloud space or in media server and the contents are access by exhibit things through gateway. The gateway provide the wired or wireless connectivity between cloud space / server.

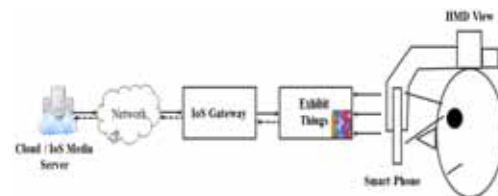


Fig. 5. Light ID based Interactive Exhibits Block Diagram

The visitor connect with Light ID of the exhibit things through HMD-AR and first decode the location information to access the exhibit things specific 3D virtual content from the media content server. This uses the OCC method to decode the data from Light ID and then exhibit things specific 3D virtual content request send to the media content server to access the exhibit things 3D virtual contents.

The HMD-AR reconstruct the received 3D virtual content and rendering on HMD-AR visual display area for visitors perceive the requested exhibit things media content to please the visitor perception.

### 6. Exhibits Things Immersive 3D View Emulation and Analysis Using Light ID

The proposed Light ID based exhibits things 3D virtual content emulated using Simple VR modu

le and GALAXY S8 smart phone for Jeonju Hanok Village. The Light ID generated using custom 2D color code pattern on display screen and used as Tag for exhibit things identifier and OCC communication for AR virtual content delivery. The 2D color code Light ID is decoded on smart device and send request to content server for getting Light ID specific content information delivery. The content server forward the AR 3D virtual media content to Light ID things about Light ID specific Jeonju Hanok Village exhibit things and the exhibit things transfer the media content to the visitor using 2D color code Light ID implemented on display. The emulated working scenario is illustrated in Figure 6.



Fig. 6. Light ID based Interactive Exhibition Illustration

The customized android application developed for GALAXY S8 smart phone with QCIF (176x144) virtual content resolution and 3 fps 3D virtual content view rate to evaluate the proposed system model and tested in real-time at Jeonju Hanok Village. The emulated system specification and performance measures are shown in Table 1.

Table. 1. Emulation Specifications and Performance Measures

Emulation Specification	No of User		
	1	2	5
AR Content Resolution	QCIF		
Capture Rate (fps)	30		
Display Rate (fps)	30		
AR Content Display Rate(fps)	3		
User Access Distance (m)	2		
RF Content Arrival Rate(sec)	0.0 4	0.0 5	0.0 9
OCC Content Arrival Rate(sec)	0.04		
Visual PSNR – RF (dB)	98. 2	98. 1	97. 2
Visual PSNR – OCC (dB)	98.2		

Table 1 confirms that Light ID based exhibits interaction to exhibit things with virtual content view provides effective performance in terms of time delay and visual quality. The time delay increase and visual quality decrease when number of user access increase in the case RF based user interactions but the time delay and visual quality is same even though the number of user access increases for OCC based user interactions. This emulation help to achieve the main objective of interactive exhibition technology is to engage the exhibition visitors with immersive 3D virtual view about exhibit things.

## 7. Conclusion

This paper proposed the Light ID based exhibit things interaction approach for HMD-AR based portable exhibition system design. The proposed system model emulated and analysed using VR case on GALAXY S8 smart phones and evaluated the system performance at Jeonju Hanok Village. In this emulation, the AR uses the automated 3D pairwise surface matching construction model on the multi-view captured static images. We have constructed the proposed Light ID based exhibit things

interaction system with user smart device and evaluated the virtual media content arrival delay and visual quality measure (PSNR) for single and multiple user access. As a result, the proposed system emulation achieves 0.04 sec delay in access the content and the PSNR is maintained 98.2 dB for single as well as multiple user interactions. This evaluation results assures that full functional implementation of Light ID based exhibit things can provide immersive 3D view in future exhibit things.

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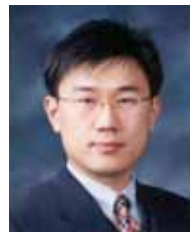


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