

# 8K Cultural Heritage Project Initiatives

## Ichitaka Takaki

Technical Producer  
Media Development & Strategy Center  
General Media Administration  
Japan Broadcasting Corporation (NHK)



## Takao Tsuda

Senior Manager  
Systems Solution Center  
Engineering Administration Department  
Japan Broadcasting Corporation (NHK)



## 1. NHK and Tokyo National Museum joint project: “Our 8K Cultural Heritage”

In September, 2020, the Tokyo National Museum and NHK began a joint research project using 8K technology titled, “Our 8K Cultural Heritage.” The joint research uses 8K and the latest scanner and photogrammetry technologies to focus on some of the national treasures and cultural properties held by the Tokyo National Museum, creating 8K cultural properties using ultra-high-definition 3D computer graphics, far exceeding video experiences created in the past.

Under restrictions on gatherings due to the COVID-19 pandemic, art galleries and museums around the world are searching for new ways to appreciate art. By combining these 8K cultural properties with various digital tools, we are pursuing ways to appreciate art in this new era, so that everyone can enjoy the cultural assets and experience a “wealth of heart and mind”. We are also presenting the results of this work at events and through broadcast programs.

NHK has produced and broadcast a television series related to this project titled “Fresh Encounters with our Cultural Heritage,” and the Tokyo National Museum plans to hold an exhibition featuring a compilation of results from this joint research in 2022, the 150th anniversary of the museum.

## 2. Created 8K cultural properties and content

8K cultural properties are extremely detailed 3D computer graphics (CG) models created using software to combine data from photogrammetry and various other sensors. So far, we have created 8K cultural properties including the seven listed below (in no particular order). For each of them, we prepared high-quality pre-rendered movies and/or interactive CG content rendered in real time, based on the original 8K cultural property CG models.

- The Kudara Kannon (held at Horyu-ji temple)
- The Goggle-eyed dogu (clay figurine)
- The Funakibon byobu screen with scenes in and around Kyoto
- The Kuze Kannon (held at Horyu-ji temple)
- A Kin-in (golden stamp, held at the Fukuoka City Museum)
- A Ko'omote-type Noh mask (Kawauchi)
- A Denyamanba-type Noh mask

### ▼ Scanning tools

The main tools used for scanning the cultural properties were the following.

■ Figure 1: Pre-rendered image of the Kuze Kannon 8K cultural property



■ Figure 2: Golden stamp 8K cultural property



- 3D laser scanner: FARO Focus350, ScanArm 2.5C
- Optical 3D scanner: AICON SmartScan
- Digital single-lens camera: SONY α7R Mark IV

### ▼ Pre-rendered movies

To create the 3D CG models, Autodesk Maya and Foundry Modo software was used, and rendering was done using Arnold. We aimed to achieve high quality, assuming the results would be appreciated on an 8K-HDR display, striving to achieve near-real reproduction of both detail and color. Rendering high-quality, high-resolution CG is time consuming, and in some cases, production of these 8K cultural properties required more than an hour of processing per frame. For the four programs discussed below, NHK performed in-house rendering of 179,020 frames in a total of 160 cuts.

■ **Figure 3: Taking photos for photogrammetry**



■ **Figure 4: Pre-rendered image of the Kudara Kannon 8K Cultural property**



We received support from Mr. Shuichi Narita of AfterImage Inc. in producing these 3D CG models.

#### ▼ **Interactive content**

With CG images rendered in real-time (real-time CG), it is difficult to achieve image quality better than pre-rendered CG images, but real-time CG has the advantage of interactivity, which cannot be achieved with pre-rendered CG. Observers can manipulate the item themselves, viewing it at whatever angle or size they desire. It is also useful in terms of efficiency, with lower production cost in many cases, depending on the length and number of cuts required.

The interactive content was produced using UnrealEngine, with collaboration from historia Inc. To avoid degrading the immersive quality of the content for viewers, we focused on maintaining resolution and a frame rate of 60 fps. When importing the original 8K cultural property data into the UnrealEngine environment, we optimized to minimize any visual effect. We used a workstation equipped with an NVIDIA Quadro RTX 8000 GPU to create the real-time CG images.

We output the interactive content to 8K displays and projectors, manipulating it with a game controller, and we also developed VR/AR content using a head-mounted display (HMD). To utilize the quality of the 8K cultural properties and facilitate immersive virtual-space content, we used a Varjo XR-1

capable of displaying high-resolution CG for the HMD.

The interactive content was all produced using the SDR color space. The photogrammetry photos are recorded as RAW data, so it would be possible to produce it with a richer color space, but considering issues such as production time and the processing load on the PC used for real-time CG rendering, we decided to use SDR. Support for HDR will be an issue for consideration in the future.

■ **Figure 5: Performer manipulating the Goggle-eyed clay figurine projected on a 450-inch screen**



### **3. BS8K program, “Fresh Encounters with our Cultural Heritage”**

NHK is also producing a TV series for the BS8K channel titled “Fresh Encounters with our Cultural Heritage” (<https://www4.nhk.or.jp/P6741/>). The program features various cultural properties, with the host and guests examining them from angles and close-ups that would never be possible normally, gaining a thorough appreciation of the items, speculating on the intentions and values of the creators as they do so, and enabling viewers to also share in this appreciation.

As of January, 2022, the following four programs have been produced. We created pre-rendered movies and interactive content for each of the programs, to clearly present features of each item, as required for production. Each of the 8K cultural properties is discussed more specifically below.

#### ▼ **Goggle-eyed clay figurine**

The 3D CG model of the clay figurine is composed of approximately 7.85 million polygons, using 13 8K-resolution textures. The interactive content can be manipulated using a game controller, with zoom, pan and tilt operations to rotate the figure and change the viewpoint. A user-friendly interface is provided, which can be used easily even by users not accustomed to 3D CG operations. It has a simple viewpoint-reset operation to reset the position to facing the figure, and a “B-dash” function to move the figure quickly, by holding the “B” button and operating the joystick. Another function enables the user to go inside the figure with the push of a button.

We also developed VR content that enlarges the figurine by

500-times and lets the user move around inside the figurine.

■ **Figure 6: Performer wearing an HMD and the clay figurine VR content**



▼ **Funakibon byobu screen with scenes in and around Kyoto**

The Funakibon byobu screen portrays more than 2,700 people of influence, such as samurai, as well as shopkeepers and other commoners. To be able to show each of the people on the screen magnified on an 8K display, the CG model required textures with extremely high resolution. The 8K cultural property of the Funakibon byobu screen with scenes in and around Kyoto uses

■ **Figure 7: Pre-rendered image of the 8K cultural property, “Funakibon byobu screen with scenes in and around Kyoto”**



■ **Figure 8: Interactive content: Zooming to see people’s facial expressions**



210 8K-resolution textures (which are actually divided into 840 4K-resolution images). This comprises over 100 GB of data, so it was impossible to load the entire set of textures into the GPU for display. By implementing careful high-speed processing to swap textures according to the camera distance and the area being displayed, we were able to implement seamless operation without losing detail, regardless of the magnification of the byobu screen (so-called level of detail (LOD) processing). With simple LOD processing alone, it is difficult to avoid noticeable texture switching, so before recording the TV program, we adjusted various parameters such as display timing on a trial and error basis to find the best settings.

▼ **Kudara Kannon**

The first program in the series dealt with the Kudara Kannon, and preparation involved was really a learning process. The 3D CG model consisted of approximately 4.8 million polygons and 21 8K-resolution textures. In the studio we displayed the pre-rendered CG on a 1.6 m by 3.6 m LED display built on the set, to create a photo-real, actual-size display. We also developed interactive VR content that gives a sense of scale while wearing the HMD by showing the Kudara Kannon image over the Japanese archipelago, and AR content that allows very close observation by integrating the Kudara Kannon image with live images inside the HMD. In the program a Buddha sculptor attempts to carve a replica using this AR content.

Normally with VR and AR, some method is used to detect the location of the HMD and its motion is linked to a camera in the CG space to display the CG at the corresponding position in the HMD. In this case, we developed a function using a similar mechanism, using a controller attached to the HMD to move the camera in CG space, so the controller can be used instead of the HMD to set the camera position for the CG shown on an 8K display connected to a workstation. Using this function, after recording the program, the presenter’s movements were reproduced using the controller, and the video seen by the presenter in the HMD was simulated as 8K video. This was output and recorded on P2. This arrangement was also used later

■ **Figure 9: Kudara Kannon 8K cultural property built into the studio set**



for the Goggle-eyed clay figurine content, and was effective for events during the COVID-19 pandemic.

#### ▼ Kuze Kannon

The 3D CG model of the Kuze Kannon consists of approximately 6.65 million polygons and 17 8K-resolution textures. For interactive content, we developed two features: 1) Content that enables the Kuze Kannon to be appreciated on an 8K display or 8K screen from any viewpoint, using a game controller, and 2) AR content that enables the operator to pick up the CG Kuze Kannon and move it around using the HMD controller. In the TV program, a researcher in the studio uses this AR content, attempting to place the Kuze Kannon image appearing in the HMD onto a virtual pedestal. We also developed a system described below, to share the Kuze Kannon CG with remote locations (Tokyo, Nara), and conducted a “Digital research conference”.

■ Figure 10: Interactive content video of the Kuze Kannon 8K cultural property



## 4. Non-broadcast exhibitions

### ▼ Tokyo National Museum exhibit event

In March, 2021, an event exhibiting our 8K cultural properties, together with a press conference, was held at the Tokyo National Museum. The interactive content for the Funakibon byobu screen with scenes in and around Kyoto was projected in 8K onto a large screen. Also in the exhibit were real byobu screens and PV of the 8K cultural property pre-rendered movie, on an 8K display playing on a loop. The Goggle-eyed clay figurine interactive content was also shown and demonstrated on an 8K display.

### ▼ Inter BEE 2020/ 2021 exhibits

For Inter BEE 2020, which was held online, a 3D scan was taken of the artistic set in the “Fresh Encounters with our Cultural Heritage” studio and presented as VR content under the topic, “8K production tour of studio and relay vehicle”.

For Inter BEE 2021, the interactive content for the Goggle-eyed clay figurine was exhibited, and many visitors were able to experience this 8K cultural property.

### ▼ Kuze Kannon image digital research conference

In June, 2021, we held a “Digital research conference” as a special part of the 8K Cultural Heritage Project. For the research conference, researchers from the NHK Science and Technology Research Labs (NHK STRL) and from the NHK Nara broadcasting station gathered to study the Kuze Kannon, a national treasure. The Kuze Kannon interactive content was installed on workstations at the two locations and projected onto 8K screens. At each location, a game controller was used to zoom in and out, and to move the 3D CG model around, and the

■ Figure 11: Projecting the Funakibon byobu screen with scenes in and around Kyoto on a large screen

