Ultra High Resolution 4K/8K Real-time CG System and Its Application

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Abstract— **We propose an 'Ultra-CG project' which promotes an extreme high-definition real-time computer graphics system with a resolution of 4K and 8K (Super Hi-Vision) which is more than the conventional HDTV. It is important for the project to study not only hardware and software requirements but also content creation methodology with which the content is displayed on extreme high-resolution display. We have first developed a functioning test system, which exhibits 'Virtual Museum' in 4K resolution to assess validity of our approach and clarify the tasks toward the further application development. The system consists of a PC with high-speed graphics cards and a 4K monitor. The real-time 3DCG software and all the CG models are built on Unity, which is a 3DCG game engine, used worldwide. We are now considering various feasible applications built on the system such as exhibition, entertainment, medical use and more. This paper describes the test system, discusses the future applications and collaboration of content creators and system engineers.**

Keywords—Ultra-high resolution video; 4K; Real-time CG; Super Hi-Vision; Virtual museum

I. INTRODUCTION

Since the HDTV digital television has become broadcast standard, ultra-high resolution imaging system has been developed over the years to achieve high presence visual experiences. The next generation of visual media such as 4K resolution (3840 × 2160) which is 4 times larger than conventional HDTV or the Super Hi-Vision (7680 × 4320) developed by NHK STRL (Science and Technology Research Laboratories) [1] producing a resolution 4 times larger than the 4K, has been developed for years and been attracting attention from media industry. These extreme high-resolution imaging systems, however, have often proceeded in a hardware priority whereas the content put in the system has been at a lower level. Although the advanced video technology has already become established, development of the market itself becomes difficult because of the lack of content.

We have started the "Ultra-CG" project to promote extreme high-resolution real-time CG (Computer Graphics) owing to the remarkable progress of CG technology. It aims to figure out solution of the lack of contents in the 4K/8K video industry. As a start, we have developed a real-time CG system with a 4K resolution by assembling commercially available video components. We have also produced a content consisting of a "Virtual Museum" built on the 4K system in order to make the best of the systems extreme high-resolution. The system has been exhibited several times in several shows and has obtained a good reputation.

In this paper, we overview the current extreme high-resolution video industry, describe our new project named "Ultra-CG". We then introduce our functioning 4K real-time CG system and the content "Virtual Museum", and conclude with future plans.

II. EXTREME HIGH-RESOLUTION IMAGING SYSTEM AND REAL-TIME CG

First we will take a look at the current circumstances of the existing extreme high-resolution video system. Here, we target only the systems to ensure a single image not a video with a so-called "multi-screen" tiled distribution. Currently, extreme high-resolution video systems are primarily referred to so-called "4K" with a resolution of 3840 × 2160 and the Super Hi-Vision (often called as "8K", hereafter referred to as 8K) whose resolution is 7680 × 4320. HDTV, which has a resolution of 1920 × 1080, is not usually referred to as extreme high-resolution because HDTV is already a digital broadcasting format regarded as standard television. However, the video system in smartphones and tablet computers other than TV have various resolutions, such as the case with the video game with real-time CG discussed in this paper. HDTV should often be referred to as high-definition video.

A. Extreme high-resolution imaging system

In the video equipment industry, a series of technical developments of the 4K video system has already been completed. Development of a set of camera, recorder, editing machine, transmission equipment and display monitor is almost available at the consumer level already. On the other hand, the absolute amount of 4K content is very little as the 4K broadcast is not scheduled, thus the main use of 4K video for consumers is to provide a 4K video upconverted from HDTV video

sources. Other than broadcast applications, the movement to deploy in a 4K digital cinema standard using 4K cameras named "RED" manufactured by Red.com Inc.[2] is thriving especially in the United States. However, there is little demand placed on this technology in the film industry having limited applications such as event applications, medical applications, design reviews etc.

Next, speaking of 8K (equivalent to Super Hi-Vision), the technology has been driven by NHK STRL, which is ultimately aimed as a broadcast standard. According to the NHK STRL, the Super Hi-Vision broadcasting is planned to start from 2030. Currently, development of 8K camera, recorder and displays have been made however, it is very limited as it is in the early stages. 8K is now mainly used in large-scale event application since there are many years yet to launch broadcasting 8K.

As mentioned above, the lack of content will become a significant problem in the 4K and 8K. As this industry traditionally is technology driven not content driven. So far, there is little 4K content available other than 4K cinem, and even less content available in 8K. Because of this the market is not yet developed.

B. Extreme high-resolution CG

Video systems using real-time CG have been in use for many years such as in game, events, simulators etc. Resolution of HDTV, which is 2K, is even treated as high-resolution in real-time CG.

As for the HDTV, real-time HDTV CG for virtual studio is being used on a daily basis because HDTV digital television has already broadcast. Other real-time HDTV CG applications such as those used in events use ordinary technology. However, if you see the game industry, HDTV-compatible video games are available but few games support full HDTV. This is due to the increase in cost for creating high-resolution texture images.

Real-time CG of 4K is very much limited, although there are some in games and applications of large-scale events. It is considered that the CG technology itself seems to be sufficient to withstand the demands of the 4K quality, however, a 4K game is yet to be released. Furthermore, real-time 8K CG does not exist at all. We can see only an 8K CG artwork, which is made by off-line rendering.

Although extreme high-resolution real-time CG is technically possible, this is still an area of future work. In particular, you can postulate that the real-time CG of 8K is a complete unknown area of research and development.

III. PROPOSAL OF ULTRA-CG

In accordance with the circumstance of extreme high-resolution video system and the real-time CG which is described in the previous section, we have launched a research and development project named "Ultra-CG" to further develop production capabilities of extreme high-resolution real-time CG.

The recent development of computer graphics is remarkable in terms of both hardware and software. In recent years, CG technique has become an essential means of expression in many areas such as TV production, cinema production, interactive game, simulator, and event content. The power of CG expression has already reached at high level and it is often said that no further advancement is needed for CG techniques. Also in content creation, many creators are working worldwide and they keep on showing the unprecedented enhancement of CG content creation. Furthermore, as advances in hardware and Graphic Processing Units (GPUs) now perform extreme high-speed graphics computation, dramatically faster, even a general PC equipped with a GPU renders real-time CG with no stress.

On the other hand, extreme high-resolution CG works of 4K/8K is still an unexplored field. This can be said in regards to the work of live-action footage as well. We have to seek out content utilizing the characteristic of extreme high-resolution instead of producing content with previous approaches, within HDTV methods and standards. Nevertheless from the side of the creators, it is an inexperienced area that offers a substantial challenge.

Based on the above background, the objective of the Ultra-CG project is to promote the production of new content built for the extreme high-resolution system, to balance advancements in technology with corresponding developments in content and facilitate an expansion of the 4K and 8K market itself.

IV. REQUIREMENTS OF ULTRA-CG

In Ultra CG, it is important to organize hardware, software and content in a balanced way. Figure 1 illustrates optimal functionality. The details of this are explained below.

A. Hardware

Firstly, high-speed machines capable of performing complex real-time CG calculation are required. Recent graphic chip manufacturers such as, AMD (Advanced Micro Devices, Inc. [3]) and Nvidia [4] are inexpensive but super high-speed graphic cards for consumers. We believe that this technology is sufficient and that we should not require special hardware and software in order to provide more content creators the opportunity to contribute to the system. Next, the establishment of an integrated system assembling the PC with the graphic card video out-put signal connected to a video display, recorder

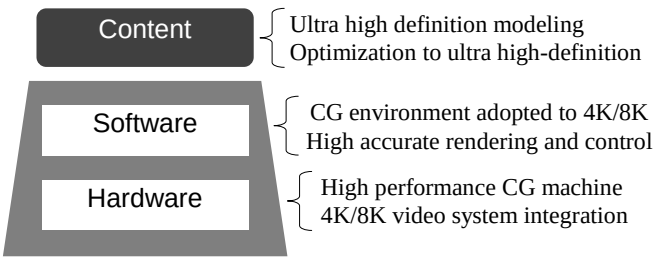

Figure 1. Requirements of Ultra-CG

and so on. This will be done in accordance to 4K/8K requirements of a high-speed video signal rates and potentially the ability to incorporate real-time video capturing hardware of HDTV or 4K so that we can import movies into the 3DCG space.

B. Software

Firstly, the system requires a software environment that can render 4K/8K extreme high-resolution CG in real-time. It is desirable to use commonly used real-time CG platforms to facilitate easy adaption for content creators. An optimal strategy would be to prepare a general-purpose OS such as Microsoft Windows machine as rendering hardware. In addition, a software environment capable of using ultra-high-resolution texture images in addition to necessary output video resolution is required.

C. Content

Finally, the CG content built on the hardware and software as described is required to withstand extreme high-definition of 4K/8K. As mentioned in the previous chapter, not only high-resolution video production but also novel ideas, designs and expressions created to meet the demands of the improved capabilities of this new and unique form of 4K/8K extreme high-resolution video, will be needed. In particular, there are two viewing experiences in common use. One is the standard viewing distance in which the display size is often quite large. The other is a very close distance from relatively small monitors. In this case, the viewer can observe extreme detail in the image very clearly. We think that the former one is primary as part of the conventional video production, however, the latter one has not yet been fully pursued. Thus we need to explore the latter more to further investigate possibilities and potential difficulties. A video system satisfying requirements for both viewing distances may require additional special technology, and hardware.

We have described three issues as shown in Figure 1. Our priority is to develop these three areas in a cooperative balance.

V. PROTOTYPE OF "VIRTUAL MUSEUM"

We have created a prototype for 4K real-time CG content built in accordance with 4K hardware, software and Ultra-CG requirements as described in the previous chapter. The first model case of our project is a "Virtual Museum of Ukiyo-e (Japanese woodblock prints)" exhibited on the 4K monitor.

Figure 2 shows the system configuration. We use a generic PC "Quad-CORE" equipped with a graphics card "V7900" manufactured by AMD with a Microsoft Windows7 OS. The four Display-Port outputs from the card are converted to four DVIs, which are connected to a 56-inch professional-use 4K monitor; the "DM-3410-A" manufactured by Astrodesign Inc. [5] The software, we use is "Unity" by Unity Technologies [6] which is a platform for creating 3DCG games that is widely used throughout the world today and has been for several years.

First, we model the museum 3D space with several art works and export the CG data (using 3ds) and import these

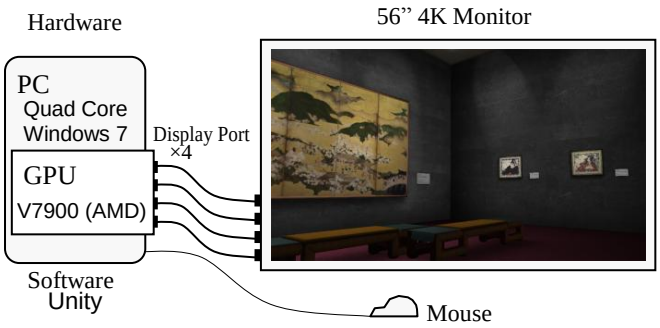

Figure 2. System configuration

assets to the Unity 3D space. We then create a walkthrough program on Unity to allow users the ability to walk around and explore the space and examine the art works freely. The texture images used to model the museum are more than 20 pieces of 4096 × 4096 images. There are also 15 light sources including nine point lights illuminating each work of art. The art works in the museum space are seven images of woodblock print (4096 × 4096 per piece). These are digitized with a scanner and an image of a big folding screen of large landscape (using two 4096 × 4096) digitized photographic images. Other elements such as picture frames, dated captions etc. are also created as 3D CG data.

Figure 3 shows the output of the virtual museum prototype. Due to the simple geometry of this particular museum space including pictures, the number of polygons required is only about 5000. However, due to the large amount of textures and the required resolution as described above. The walkthrough program runs well when the option of best rendering quality ("fantastic”) is selected in the 3840 × 2160 resolution. The walkthrough operation is very smooth where it obtains more than 60 fps with a wide margin. Because of the ultra-high resolution texture images used for each work of art, the surface of the paper with its subtle texture, stain or dirt can be clearly observed when viewers approach the works of art as shown in figure 3.

We have demonstrated the virtual museum at the exhibition several times the responses have been overwhelmingly positive impressing many viewers. It was recognized as one of the promising ways of using 4K content effectively, which is in need of content. We think it might also be good to have chosen subjects of Ukiyo-e: Japanese woodblock prints as the art work in the virtual museum. Ukiyo-e is usually exhibited only in dim light to avoid fading. In addition, due to the small size of the works of art (usually the size of B4 or B5) viewers can barely observe any of the interesting and beautiful details. In contrast to an inconvenient way of seeing in the real Ukiyo-e museum, viewers can enjoy all of the details at a very close distance with bright illumination and off site.

VI. CONCLUSION AND FUTURE OF ULTRA-CG

In this paper, we describe an Ultra-CG project to promote the extreme high-resolution 4K/8K real-time CG. As a first step in this project, we introduce the prototype of 4K real-time virtual museum system. The content creation platform of 4K/8K, which exceeds conventional HDTV, may require new technique not yet implemented in terms of both technology and content. Our ambition is to examine the possibilities of the above technique and explore future content in this project.

We conclude with our plan for future development. First, we will expand the prototype 4K real-time CG system with a single graphic card to 8K resolutions by using four graphic cards. There are various problems with synchronous operation of a number of cards, needed to cope with 8K resolution in Unity and the high-resolution textures and models. In addition, for both 4K and 8K, we will realize a capability of accommodating running movies in the 3D CG space together with 3D sound effects. Tests will be conducted with commercial graphics cards, to measure performance in advance in order to detect the maximum number of polygons, the amount of textures and number of light sources.

The contents of this project and the creation of this virtual museum is just one of the many possible examples and applications for the future. We would like to develop a variety of content that makes the best use of ultra-high resolution 4K/8K. Therefore, we will widely recruit personnel responsible for the content creation such as CG creators, designers and artists, while advancing collaboration with art universities. In particular, because we use Unity which is popular worldwide as a game making tool, we would like to develop new content by providing our Ultra-CG platform worldwide to organizations and human resources who are involved in making 3DCG games. Also, we think that the output of Ultra-CG should not only be limited to 4K displays but should also be displayed by big projectors using for example, projection mapping techniques in large-scale events.

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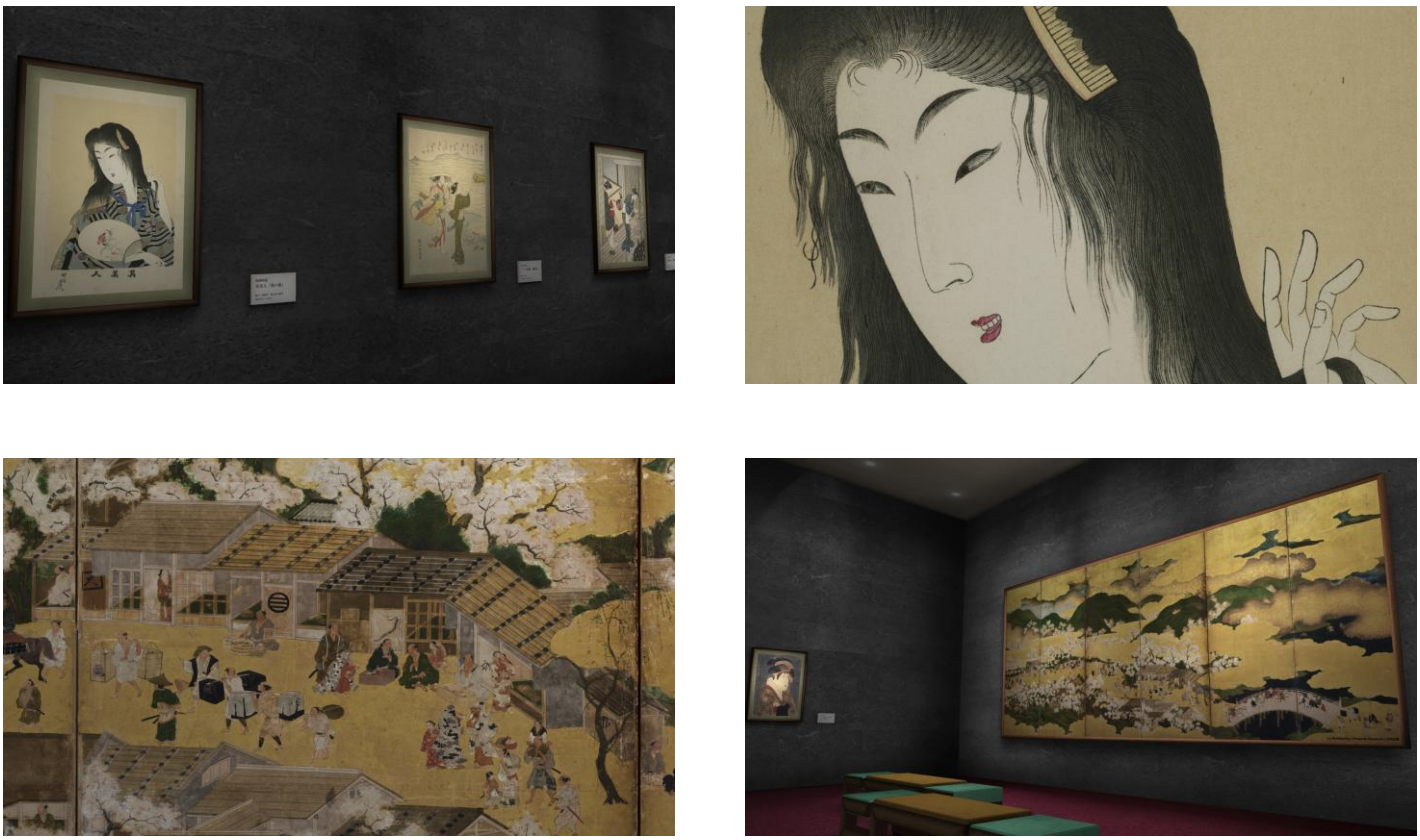

Figure 3. Output images of virtual museum prototype