Development Framework for Web-based VR Tours and Its Examples

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***Abstract*— This paper treats a development framework for web-based VR tours of 360VR camera images/videos and lidar scanner data and introduce several example VR tours actually developed using the framework. Because of the advancement of XR(VR/AR/MR) technologies such as lidar scanners, 360VR cameras and high specification VR goggles, the demand of XR applications has become increased. However, the development of such XR applications is tedious work that needs much time. Therefore, the authors have proposed the development framework for web-based VR tours of 360VR camera images/videos and lidar scanner data and this paper introduces it and several VR tours as its examples.**

Keywords—VR tours, Development framework, 360VR camera, Lidar scanners

I. INTRODUCTION

In this paper, we introduce the development framework for web-based VR tours using 360VR camera images/videos and lidar scanner data(PCD: Point Cloud Data) and also show several VR tours as the development examples of the framework. Recently, many companies release 360VR cameras and 360VR images/videos have become popular. By using 360VR images/videos, it makes possible to develop more immersive VR tours that attract more users than using standard 3D-CG. However, the development of such immersive VR tours is tedious work that needs much time. Therefore, we have proposed the development framework[1] that supports 360VR camera images/videos and lidar scanner data, and developed several VR tours as the development examples of the framework.

There are many commercial services for creating VR tours. If we do not need to consider their cost, we can use such services. Actually, we have to consider their cost and to spend much money because there are many demands of such VR tours in our university for public relations, education purposes and so on. This is another reason why we propose the development framework for VR tours.

The remaining parts of this paper are as follows: next Sec. 2 describes related works. We introduce several conventional tools and services and explain the differences of our proposed framework from them. In our framework, before creating VR tours, we have to prepare three types of media data, i.e., 360VR images/videos and Point Cloud Data(PCD), Sec. 3 describes what kinds of scanning devices and what kinds of dedicated software tools are used for preparing those media data. In Sec. 4, we introduce the proposed framework and explain its functional details using VR tour contents of our university library as the development examples. Sec. 5 shows another VR tour example to clarify the usefulness of the proposed framework and educational VR contents. Finally, we conclude the paper and discuss about future work in Sec. 6.

II. RELATED WORKS

When creating interactive 3D applications, we have to use any toolkit systems. There is *IntelligentBox*[2] that is a development system for interactive 3D desktop applications proposed by our research group. There have been many 3D desktop applications and 3D web applications actually developed using *IntelligentBox* and the web-version of *IntelligentBox* (WebIB)[3] so far. However, *IntelligentBox* and WebIB do not support 360VR images/videos. Unity[4] and Unreal engine[5], the most popular development systems in the world, are very powerful and possible to create web 3D contents besides standard 3D applications. By using Unity, it seems possible to develop the same framework as our proposed one. However, once we used Unity, we have to use Unity whenever we want to modify and extent the functionalities of our framework. Because Unity is one of the commercial products, if we want to make our framework be open, we have to spend much money. Therefore, we did not use Unity. Our framework consists of several our own JavaScript programs and free JavaScript libraries like Three.js. We can release our framework as open software as we wish.

As commercial services, there are those of THETA 360.biz[6] and Matterport[7]. The service of THETA 360.biz[6] does support 360VR images. It provides an web-based editing tool for 360VR image contents. Using this editing tool, even end-users can create their own 360VR image contents. Unfortunately, our proposed framework does not provide such an web-based editing tool for 360VR image contents. In our framework, the user have to record manually the locations in the real world where each set of fish-eye lens images taken by a 360VR camera. After that, the user have to generate 360VR images from the set of fish-eye lens images by stitching them into one image called an equirectangular image using its dedicated software. When creating a VR tour of

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360VR images, the things the user have to do are storing generated 360VR image files and their location information into the framework. This is not much time-consuming task. The other difference between THETA 360.biz service and our framework is that our framework does support 360VR videos and PCD data besides 360VR images although TEHTA 360.biz does not support 360VR videos and PCD. The service of Matterport [7] does support 360VR images and PCD, i.e., Lidar data simultaneously captured. It provides a powerful tool based on AI technology called Matterport capture application that automatically generates a location map of 360VR images and PCD. As explained above, unfortunately our framework does not provide such function. This is one of the shortcomings of our framework in comparison with Matterport service. The other difference between Matterport service and our framework is that our framework does support 360VR videos besides 360VR images and PCD although TEHTA 360.biz does not support 360VR videos.

III. Preparation for Media Data

As explained above, our proposed framework supports mainly three types of media data, i.e., 360VR images/videos and PCD. Before developing VR Tour contents, we have to prepare such media data,. In this section, we describe what kinds of scanning devices and what kinds of dedicated software tools are used for preparing those media data.

Fig. 1. Image of sensing devices of Insta360 Pro(Left), Insta360 one X2(middle) and Leica BLK360(right).

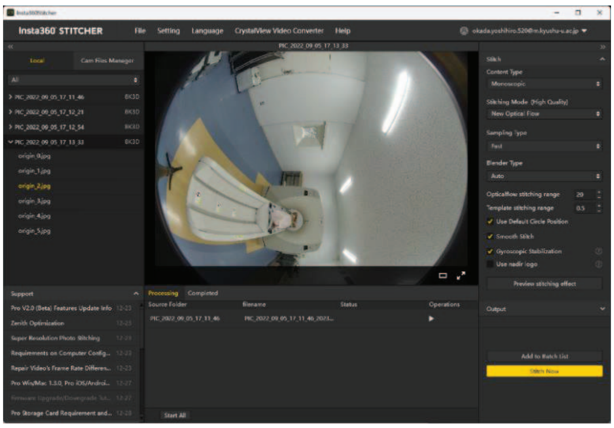

Fig. 2. Screen image of Insta360 STIICHER..

A. *Scanning device for 360VR images/videos and its software*

As sensing devices for 360VR images and 360VR videos, we use Insta360 Pro and Insta360 one X2, respectively as shown in the left and middle parts of Figure 1. Once we obtain fish-eye images/videos by scanning any real-world rooms or buildings, we can use Insta360 STITCHER, a dedicated software to generate 360VR images/videos called equirectangular images/videos by stitching the scanned fish-eye images/videos. The screen image of Insta360 STITCHER is shown in Figure 2.

B. *Scanning device for Point Cloud Data(PCD) and its software*

As a scanning device for Point Cloud Data(PCD), we use Leica BLK 360 shown in the right part of Figure 1. The BLK360 captures the world with full-color panoramic images overlaid on a high accuracy point cloud easily by the single button. Once we obtain PCD by scanning any real-world rooms or buildings, we use Cyclone REGISTER 360 (BLK Edition), a dedicated software that processes scanned PCD to generate merged PCD. The screen image of Cyclone REGISTER 360 is shown in Figure 3.

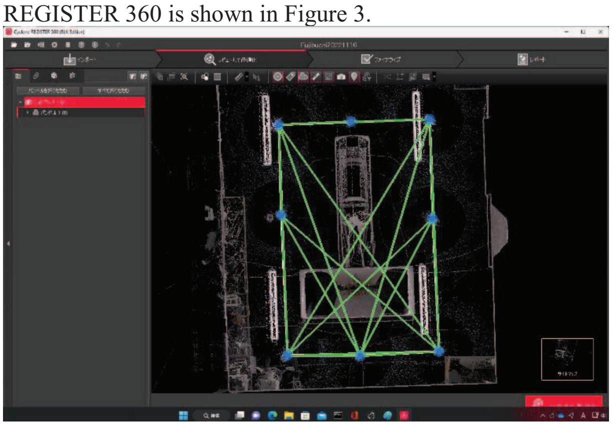

Fig. 3. Screen image of Cyclone REGISTER 360

IV. Proposed Framework

Our proposed framework supports the three types of media data such as 360VR images/videos and PCD. So, in the framework, there are three individual systems those are for walkthrough-based VR tours of 360VR images, for navigation-based VR tours of 360VR videos and for walkthrough-based VR tours of PCD. The all HTML and JavaScript files of the three systems are shown in Figure 4.

The system for walkthrough-based VR tours of 360VR images includes walk_map.html, walk_map.js and walk_map_controls.js, the system for navigation-based VR tours of 360VR videos includes video_map.html, video_map.js and video_map_controls.js, and the system for walkthrough-based VR tours of PCD includes pcd_map.html, pcd_map.js and pcd_map_controls.js. THML files are used to define the web-page layout of each VR tour with some text information. Walk_map.js, video_map.js and pcd_map.js are main JavaScript programs of the proposed framework. Each of them works with several web 3D graphics functions derived from Three.js library [8]. You do not need to modify these programs when creating new contents. The required things you have to do are very simple, i.e., storing media files of

PCD and 360VR images/videos in Assets directory, and setting their file names in each of walk_map_controls.js, video_map_controls.js and pcd_map_controls.js. Each of these JavaScript programs plays a role to load required media files and to read the location information where 360VR images/videos were taken those are referred in each main JavaScript program.

walk_map.html
video_map.html
pcd_map.html
JS {
walk_map.js,
walk_map_controls.js,
video_map.js,
video_map_controls.js,
pcd_map.js,
pcd_map_controls.js
}
	JSM {
	Several JS files from Three.js library
	}
	Assets
	Images { 360VR images, optional images }
	Videos { 360VR videos }
	Models { PCD files, optional 3D model files }
	Movies { optional movie files }
	Sounds { optional sound files }

Fig. 4. Files for the three system of the proposed framework.

As assets, besides 360VR images/videos and PCD, there are optional media files, i.e. images, 3D models, movies and sounds. The supporting these optional media files is one of the remarkable points differ from the commercial services like THETA 360.biz and Matterport. Using the proposed framework, we actually created the VR tour contents of our university library building as one of the activities for our open campus event held in August, 2022. In the followings, we explain each system of the proposed framework individually using these VR tour contents and how the optional media files are used in them.

A. Walkthrough-based VR tours of 360VR images

Figure 5 includes four screen images of the walkthrough-based VR tour of 360VR images those of 3rd floor of the library building. Figure 6 shows four 360VR images, i.e., original equirectangular images. Each of them corresponds to each of the four screen images of Figure 5. The middle image of Figure 6 is the map of 3rd floor. It is the same one appears in the left upper part of each screen image of Figure 5. As you see, many orange dots totally over 100 are displayed on the map. Each of them indicates the location where each 360VR image was taken by 360VR camera. By mouse-button clicking on one of the orange dots, its corresponding 360VR image will be loaded and displayed as the next 360VR scene. Similarly, there are thin grey cylinders in each 360VR scene. By mouse-button clicking on one of them, its corresponding 360VR image taken at the same location will be loaded and displayed as the next 360VR scene.

As explained above, the framework supports optional media files. For instance, for additional explanations of special locations, a standard movie appears in the 2nd screen image and a standard image appears in the 3rd screen image of Figure 5. Besides grey cylinders, there are red spheres in 360VR scene. By mouse-button clicking on one of them, its corresponding standard movie or image will appear like in the 2nd or 3rd screen image. Also, as shown in the 4th screen image of the figure, there is a yellow sphere close to the stairs. By mouse-button clicking on it, you can move to downstairs or upstairs interactively. Furthermore, you can easily understand where you are located by looking at a red marker displayed on the left upper map of each screen image that indicates your current location and direction.

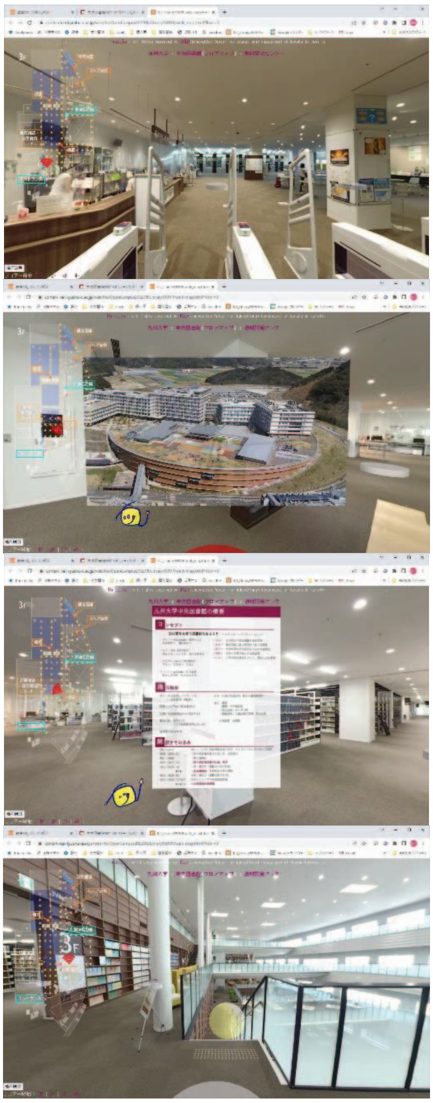

Fig. 5. Four screen images of the walkthrough-based VR tour of 360VR images those of 3rd floor of the library building.

Fig. 6. Four 360VR (original equirectangular) images and 3rd floor map.

B. Navigation-based VR tours of 360VR videos

Figure 7 includes one map and three screen images of the navigation-based VR tour of 360VR videos those of 3rd floor of the library building. A control panel is located in the lower middle part of each screen image for managing its 360VR video, i.e., play/pause, forward/backward, and play speed up/down. The 360VR scene is automatically changed into the next one corresponding to the current playing point of the 360VR video. Therefore, this type of VR tour is called navigation-based one. The left upper part of each screen image of Figure 7 is the map of 3rd floor same as the left upper part of the figure. As you see, there are cyan arrow lines on the map. These arrow lines mean the moving path actually the person wearing 360VR camera on the top of his/her head moved through when taking this 360VR video. By mouse-button clicking on one of the arrow lines, the 360VR video will be jumped to the corresponding point and its corresponding 360VR scene will be displayed. Similar to the system for walkthrough-based VR tours, this system also supports optional media files such as standard image files. For example, in each of the two screen images of the right part of Figure 7, there is an image file displayed on its center as the explanation panel related to its location.

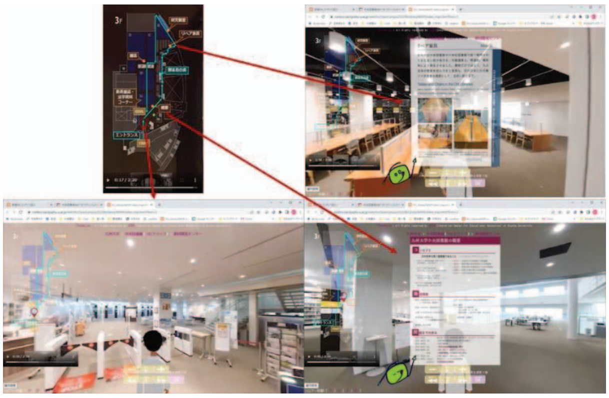

Fig. 7. One map and three screen images of the navigation-based VR tour of 360VR vidoes those of 3rd floor of the library building.

C. Walkthrough-based VR tours of PCD

Figure 8 includes four screen images of the walkthrough-based VR tour of PCD scanned by a Lidar scanner those of 3rd floor of the library building. Each of these four screen images corresponds to each of the four screen images of Figure 5. The operations of this walkthrough-based VR tour of PCD are almost the same as those of the walkthrough-based VR tour of 360VR images. This system also supports optional media files as shown in the two screen images of the upper part of the figure, a standard movie(left) and a standard image(right).

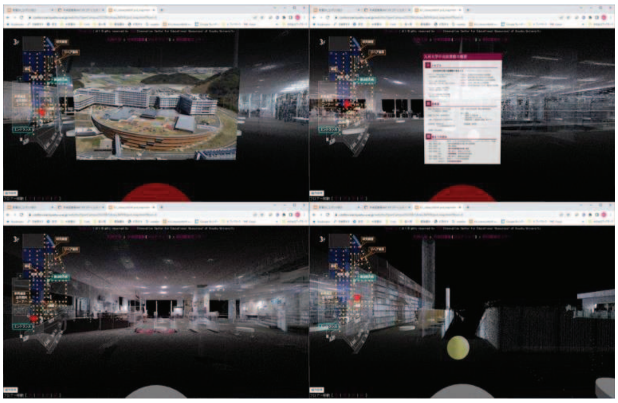

Fig. 8. Four screen images of the walkthrough-based VR tour of PCD those of 3rd floor of the library building.

V. VR TOUR EXAMPLES

In this section, first of all, we introduce VR tours of our university museum. Especially, we explain additional functions of the framework newly added for the VR tours. After that, we introduce VR tours of Isotope center and CT exercise room for education purposes.

A. VR tours of university museum

Figure 9 shows the walkthrough-based VR tour of 360VR images those of the exhibition room located on the 3rd floor of our university museum building. On the map of the left upper part, there are many orange dots totally over 20 each indicates the location where each 360VR image was taken by 360VR camera. We took 360VR images totally five sets those are corridors of the four floors and the exhibition room.

The current framework can support 3D model files besides media files like standard image files and movie files. Figure 10 shows the same exhibition room with a 3D skeleton model. By focusing your eye point onto a certain already defined point of the 360VR camera image, its corresponding 3D model will be loaded and displayed like this.

Visitors of a museum want to watch and understand deeply exhibit objects. For supporting this, additional standard 2D images can be displayed as shown in the right part of Figure 11. The left part is the normal view image, and when the user focuses his/her eye point onto a certain already defined point, its corresponding higher resolution 2D image will be loaded and displayed as shown in the right part. The user can watch the details of exhibit objects.

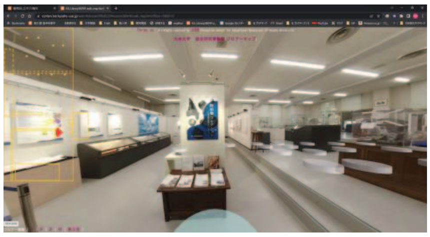

Fig. 9. Screen image of the walkthrough-based VR tour of 360VR images those of the exhibition room of the university museum building.

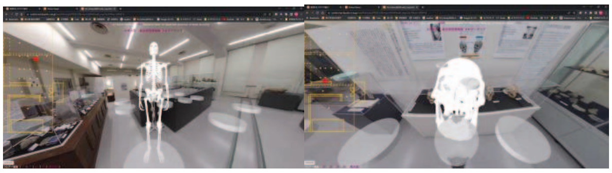

Fig. 10. Two 360VR images with a skeleton model and with a skull model.

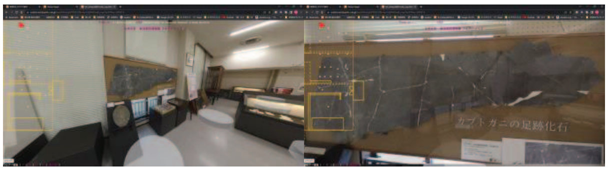

Fig. 11. Two 360VR images without and with a corresponding explanatory image.

The upper part of Figure 12 shows the navigation-based VR tour of 360VR videos those of the same exhibition room. One of the museum staffs wearing a helmet with a portable 360VR camera located on the top of the helmet walked in several rooms. In this way, the museum staffs recorded 360VR videos of totally nine rooms including the exhibition room.

The lower part of Figure 12 shows the walkthrough-based VR tour of PCD those of the same exhibition room. Although the operations for the walkthrough-based VR tours of 360VR images and PCD of the library building introduced in Sec. 3 are almost the same, the operations for this VR tour of PCD are not the same because we uses the web-viewer for PCD proposed in the paper[9]. In this VR tour of PCD, there are not any thin grey cylinders in the scene and the user can move freely by mouse device operations.

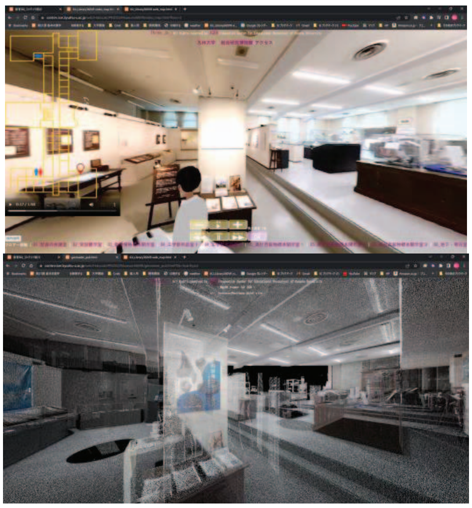

Fig. 12. The navigation-based VR tour of 360VR videos (upper) and the walkthrough-based VR tour of PCD (lower) those of the exhibition room of the university museum.

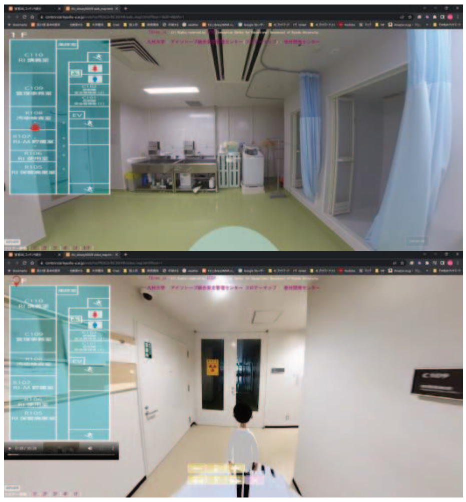

Fig. 13. The walkthrough-based VR tour of 360VR images (upper) and the navigation-based VR tour of 360VR videos (lower) those of the isotope center building of Kyushu university.

Fig. 14. The walkthrough-based VR tour of 360VR images (upper) and the navigation-based VR tour of 360VR videos (lower) those of the isotope center building of Kyushu university.

B. VR tours of Isotope center and CT exercise room for education purposes

Because the entry and the exit of Isotope center are strictly controlled, VR tours are helpful for students before their radiation experiments. Figure 13 shows the walkthrough-based VR tour of 360VR images and the navigation-based VR tour of 360VR videos those of the isotope center of our university. It needed less than a couple of hours to take 360VR images/videos. Furthermore, it needed less than one day to create these VR tours by using the proposed framework.

Due to the same reason, the entry and the exit of CT exercise room are strictly controlled. Therefore, VR tours are helpful for students. Figure 14 shows three screen images of the walkthrough-based VR tour of 360VR images(upper), the navigation-based VR tour of 360VR videos(middle) and the walkthrough-based VR tour of PCD those of the CT exercise room. Similarly to the VR tours of Figure 13, it needed less than a couple of hours to take 360VR images/videos and PCD. Furthermore, it needed less than one day to create these VR tours by using the proposed framework.

VI. CONCLUSION AND FUTURE WORK

In this paper, we proposed the development framework for creating web-based VR tours using 360VR images/videos and Point Cloud Data(PCD). Recently, XR(VR/AR/MR) applications has become popular due to the advancement of XR technologies and their great demands. However, the development of XR applications including VR tour applications is not easy and needs much time. Therefore, we made the development framework for VR tours that support 360VR camera images/videos and PCD of lidar scanners. We showed several VR tour contents to clarify the usefulness of the proposed framework in this paper. The proposed framework can allow us to easily create XR applications like VR tours without using any commercial services.

Currently, our framework requests users to prepare one JavaScript program called walk_map_controls.js for walkthrough contents of 360VR images, another one called video_map_controls.js for navigation contents of 360VR videos and the other one called PCD_map_contrls.js for walkthrough contents of PCD. The most parts of these files are the definitions of variables such as location data where the media data were taken, media file names and so on. The preparation for these files is not so much time-consuming. However, as future work, we will try to develop a web-based editing function like the service of THETA360.biz that allows users to create VR tours without preparing these JavaScript programs. Also, we will try to implement an automatic map generation function like the service of Matterport.

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