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Development of Virtual Reality Based Contents for the Practice Education of MRI

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— Abstract —

Application areas based on virtual reality (VR) can lead to change the medical and healthcare industries, and they are applied throughout the medical areas such as surgery, treatments, rehabilitation, and so on. The purpose of this study was to develop 'VR magnetic resonance imaging (MRI)' using the technology to establish virtual space, graphic development, audio insertion, shooting for special effects, etc. so as for students to understand the preparation and exam processes of the MRI test and enhance their practice capabilities. Also, it was to propose the new direction of experiencing practice education for medical devices in the radiology using VR which is the core technology of the fourth industry. The flow chart was organized using the video to develop VR-based MRI contents and user interface (UI) image files developed for interaction with VR devices. The contents were organized with cautions during the MRI test, selected questionnaires, consent form for the contrast medium, and the test types; and UI image files for interaction that could answer to questions were added to enhance the interaction with users. First, detailed methods for the MRI test and flow chart were prepared. They were based on the general moving lines of patients and testers in hospitals, and the shooting was performed including the preparations and cautions for the test. The computer graphics were developed and realized for patients to be able to select the answer 'Yes' or 'No' to the tester's questions on the selected questionnaires and consent on the contrast medium using VR device. 2D computer graphic source was produced to insert the infographics and captions inside the 360-degree video contents. The authors developed the contents to be able to perform MRI practice education using VR which is the core technology of the fourth industry.

VR MRI contents enabled to select the required parts only and study repeatedly without any limitation of time and space. Also, they can experience them free from the infections and relationship with patients. This study was aimed to propose the new direction of practice education beyond the limitation of lecture-style education.

Key Words: Magnetic Resonance Imaging, Virtual Reality, VR Contents, Practice Education, MRI Practice Education

I. Introduction

Magnetic resonance imaging (MRI) is one of the imaging technologies using the principle of nuclear magnetic resonance. If the high frequency is generated with human body in the MRI that generates the magnetic field, the atomic nucleus of hydrogen in the human body is resonated. Measuring the differences of the signals and visualizing them by reorganization through computer can be the MRI [1-2]. For the education on MRI, most colleges with radiology cannot provide practice education but theoretical classes only in reality due to the limitation not to have the expensive device. The education plans are sought to replace the practices, however, the limitations are existed to overcome the difficulty in reality. Also, clinical training is dependent on the observation program in the space beyond the restricted area since the MRI test room is strictly limited due to the high magnetic field. Clinical training can cause the infections and inconveniences to patients, and has to consider the severe infections such as MERZ or COVID-19. To overcome these limitations in reality, it is necessary to establish the system to be able to experience the MRI test situation indirectly, and one option is to develop the contents that support the clinical training applying VR.

Application areas based on VR have leaded the changes in the medical and healthcare industries, and they are applied throughout the medical area including surgery, treatments, rehabilitation, etc. [3-5]. The VR operating theater by Simbionix, an Israeli 3D development company, provides the training on the laparoscopy [6], and Surgical Theater is used for diagnosis, surgical preparations, and training for the medical school students with its 3D model based on MRI and CT images [7]. With respect to the application cases of VR for the healthcare education in Korea, a VR education program for the CT practice was developed to be able to operate the CT device in the computer-based 3-dimensional virtual environment [8], and the contents for the practice education of tooth extraction were developed [9]. In addition, a VR-based practice device for injection was developed [10], and the educational contents for the radiation therapy were developed using VR technology [11].

The purpose of this study is to develop 'VR MRI' using the technology to establish virtual space, graphic development, audio insertion, shooting for special effects, etc. so as for students to understand the preparation and exam processes of the MRI test and enhance their practice capabilities. Furthermore, this study is aimed to propose the new educational direction of experiencing practice for medical devices in the radiology using VR, the core technology of the fourth industry.

II. Materials and Methods

1. Shooting and editing the contents of VR MRI

Insta360 Pro2 camera system was used with 6 x f2.4 fisheye lens, 120Mbps per lens, and H264 and H265 for the image codec. AAC was used for the audio codec; and 4K 120fps, 6K 60fps, and 8k 30fps were used for the images. YUVJ420P was applied for the image color space. Insta360 Pro2 camera consists of 6 lenses, and takes individually by each lens. To develop the MRI contents, the original sources taken individually were 6 outcomes, and they were integrated as one 360-degree video by stitching work. After checking screen whether it is overlapped in the stitched area, they were readjusted by fine stitching work if the overlapping remains. The primary outcome was developed by editing the original videos, separating required scenes from unnecessary ones, which reduced the size of the video file for faster and easier operation. For the edited outcome, minute shaking of the camera or movement of the ground that might occur when the objects or animals were passed nearby was adjusted by the stabilizing work. Also, correction of the color was performed for the video because the color difference could be occurred by the changed lights in the shooting environment and the surrounding light intensity due to changes of the shooting places. Also, the colors were adjusted with the most comfortable ones for naked eyes when wearing the VR device for a long time.

2D computer graphic sources were developed, and infographics and captions were inserted inside the 360-degree video contents. The effort to enhance the legibility was made considering 360-degree video in order to add infographics and the text-type of graphic sources like captions. Noise level was minimized for the embedded mic in the camera and recorders for each character, and the work to restore the live sound was performed. Lastly, rendering work was performed to convert the contents into one file per final scene (Fig. 1).

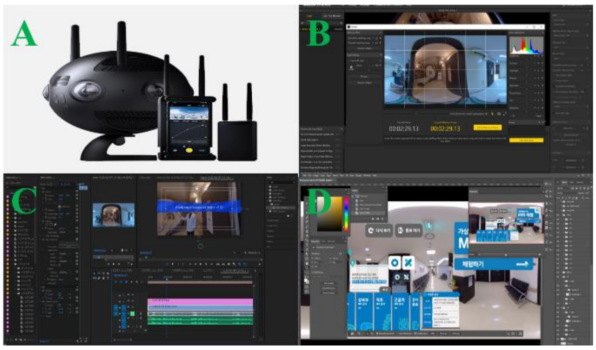

Figure 1. Shooting and editing to develop the VR MRI contents. A: Insta360 Pro2, B: Stitching the original sources, C: Stabilizer, D: Develop and insert 2D computer graphic sources

2. Flow chart for the development of VR MRI contents

A flow chart was made using the video to develop the VR MRI contents and UI image file developed for interaction with VR devices. The contents were organized with cautions during the MRI test, selected questionnaires, consent form for the contrast medium, and the test types, and UI image files for interaction that can answer to questions were added to enhance the interaction level with users.

III. Results

Contents development was successful for the practice education of the VR-based MRI. As an alternative for the practice education in colleges where the cost of MRI device was not affordable, the VR system was used. First, the detailed methods for shooting MRI and flow chart were prepared. They were organized based on the general moving lines of patients and testers in hospitals, and the shooting was performed including the preparations and cautions for the test.

1. Application and cautions

A patient who visited the hospital for the MRI test applied the registration upon the guidance of the hospital staff, and changed the dress required for the test. After changing the dress, the patient answered the selected questionnaires and consent form for the contrast media upon the guidance of the hospital staff. The patient was allowed to select the answer ‘Yes’ or ‘No’ using the VR device according to the questions from the staff on the selected questionnaires, and the questionnaires were selected from the items in ‘MAGNETIC RESONANCE (MR) PROCEDURE SCREENING FORM FOR PATIENTS’ provided by MRIsafty.com. Seven questionnaires were selected for the general information required for the test, and the questionnaires on the contrast medium was separately prepared. This is because not all patients use the contrast media for the MRI test and the students who meet the MRI at the first time require the awareness on the contrast media. The reason that all the items in ‘MAGNETIC RESONANCE (MR) PROCEDURE SCREENING FORM FOR PATIENTS’ provided by MRIsafty.com were not applied was the adverse effects, etc. from wearing the VR device for a long time. If patients completed the interaction on the questionnaires, the cautions or information on the related questionnaire was provided so as to enhance the understanding on the questionnaires.

2. MRI device and its theory

The scene was recorded to explain how the MRI device was organized, demonstrating the device in front of the MRI room. The permanent magnet and superconducting magnet were explained adding the principle of superconducting phenomena. There are multiple coils in the gantry of the MRI, and the explanations on the main magnet coil, shim coil, gradient coil, and RF body coil were added. The process to capture the MRI and its theoretical background were explained together with the components of the device. The array of the atomic nucleus of hydrogen generated when the human body is placed in the bore of the MRI device and the nuclear magnetic resonance by radio frequency pulse were explained. In addition, the differences from computed tomography (CT) or ultrasonography were explained.

3. Types of the MRI test

Among a variety of MRI tests, the tests for brain, angiography, abdomen, spine, and extremity were introduced. The purposes, test duration, methods, and cautions by each test were developed and inserted with the computer graphics. Simple explanations including the purposes and characteristics of each test were conducted. During the explanation, the patient and the tester behaved as they performed the live test, and the test order was found in the video. The tester set the position to be tested moving the coil, and the patient was positioned on the table. To lessen the noise from the MRI device, the patient wore the ear plugs and fixed them with the aide, if necessary. The patient's test part was adjusted to be placed correctly within the coil of the MRI device. For the tests of brain, angiography, abdomen, spine, and extremity, icon menu using computer graphics was produced to be added, and the type of test could be selected in the VR device.

4. Operating Console of MRI

The video was taken on the computer and monitor in the operating console, demonstrating the screen to set the pulse sequences and parameters, and some parameters were explained. The pulse sequences and parameters were produced and added with computer graphics to enhance the legibility. The screen with pulse sequences for the brain test was magnified to be shown, and multiple protocols were introduced including scout view, T1 weighted imaging of fast spin echo, T2 weighted imaging of fast spin echo, etc. The live test was performed using the starting button of scanning, and recorded with loud sound inside the MRI room from the speaker. Then, the parameters were explained including repetition time (TR), echo time (TE), number of excitations (NEX), etc. Finally, T1 and T2 weighted images in the brain were shown with computer graphics, and their differences were explained briefly.

After completion of all test processes, final shooting was performed at the registration desk. The patient changed the dress and was informed on the cautions after the test. The developed VR MRI contents can experience the process for about 20 minutes(Fig. 2).

Figure 2. VR MRI contents. A: Select O or X on the selected questionnaire, B: Feedback after selection, C: Explain the type of test in the MRI room, D: Scene to explain the MRI at the operating console

IV. Discussion

The authors developed the contents to be able to experience the MRI test using VR which is a core technology of the fourth industry. The development of contents for the MRI practice education in the colleges where the cost of MRI device is not affordable can propose the new type of VR-based practice education beyond the limitation of the theory-based education. Because the practices in hospitals should take the risks such as infections, these are considered as the necessary contents under the current COVID-19 situation. The experiencing MRI contents in the virtual reality provide students with the explanations on the device and its theoretical background to understand easier. Also, they were organized following the order of the MRI test in the hospital and intended to replace the hospital practices. They were developed with patient's preparation and actual test processes. A series of processes for the MRI test were prepared to experience them by VR, adding the explanations on the application and test processes for the MRI test, devices and protocols, parameters, etc.

The VR technology can provide users with multiple experiences that cannot be experienced easily. Using the new learning tool with

VR simulation for the healthcare images could enhance the learning capability better or similar to the existing onsite education [12]. X-ray using the 3D virtual simulation tool by Virtual Medical Coaching Ltd. could improve the effects of the practice education with the subjects of virtual patients [13]. It was also reported that the CT simulation program using VR was used in the university to show the educational effects on the radiology treatments [14]. In a study to develop the cardiac anatomy system using VR and compare it with the conventional medical education system, the VR-based cardiac anatomy system was reported to enhance the learning experiences and understanding on the anatomy [15]. The simulation training to acquire the skill required for endotracheal intubation using VR was developed to provide the environment to practice atraumatic intubation timely [16].

Likewise, VR has been diversely used in the healthcare area. The MRI device established as the subject of the contents in this study is a non-radiological device to be used in the radiology. If the experiencing programs are developed based on VR for the radiological devices such as CT, fluoroscopy, angiography, and general radiography, practice education can be conducted without exposure of radiation. In the VR contents for practice education in this study, overall application and test processes of MRI were included in view of patients, and the theoretical background and device information were added to improve the skills of the students. It would be better to produce the VR contents for the MRI test by the detailed items such as area, test, sequence, quality control, etc., however, the potential adverse effects that could occur wearing the VR device for a long time had to be considered. The VR program for the MRI test in this study was developed to experience the contents for about 20 minutes.

V. Conclusion

The authors developed the VR-based contents for the MRI practice education. This development was intended for students to repeatedly use and take the practice education of the MRI device where its installation and operation may not be possible due to its expensive price. Selecting the required part only and learning are possible whenever and wherever without limitation by the VR. In addition, they can experience it without the limitation of infection and relationship with patients. Beyond the limitation of the lecture style education, this suggested the new direction of practice education.

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