Usefulness of the Wii™ remote controller for image manipulation of MR-endoscope system

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PURPOSE An integrated MR-endoscope system can perform MR imaging during inspection and surgery with an MR-conditional flexible endoscope. This system has a software to navigate the scope location and orientation inside an MR bore and to present MR images simultaneously with the scope view. A bird's-eye view is also provided for globally viewing the target region[1, 2]. To control the navigation software in the clinical situation, an intuitive user interface is needed instead of a mouse and a keyboard. Thus we have developed an interface using a wireless accelerometer-based controller (Wii™, Nintendo Co., Ltd, Kyoto, Japan). In this study, feasibility of the image manipulation under the Bluetooth communication as well as intuitiveness of the control was evaluated.

METHODS A 1.5T MR scanner (Signa EXCITE TwinSpeed, ver.11, GE Healthcare, USA) equipped with the tracking system (EndoScout, Robin Medical, Inc., USA) was used to detect the location and orientation of the endoscope tip in the MR scanner. A user interface software was developed for the controller based on the native WiiRemote C++ class library called "WiiYourSelf!"[3]. The angles of roll and pitch of the controller detected by the acceleration sensor were sent to the image processing PC via a Bluetooth. The software was designed to rotate the MR volume data according to the motion of the controller with the 'B' button pushed down. The operation of this function was demonstrated by using the images of a porcine gastric wall, as shown in Figure 1.

Influence of the Bluetooth communication between the controller inside the MR shield room and the PC with a host adapter (PTM-UBT6, Princeton Technology, Ltd., Tokyo, Japan) outside was assessed for image quality and for tracking accuracy. Data were acquired with the following conditions; no controller was in the shield room (C1, control), stationary on the shelf shown in Figure 2 (C2) and operated near the MR scanner (C3).

First, the MR image quality was examined with a spherical phantom shown in Figure 3. Images were acquired with spoiled gradient recalled echo in steady state (SPGR) with the following conditions; TR/TE, 200/7ms; FOV, 24 x 24cm; slice thickness, 5mm; and acquisition matrix, 256 x 128. A Spin echo (SE) with TR/TE, 500/12ms, as well as a Fast Spin Echo (FSE) with TR/TE, 4000/104ms; echo train length, 16 were also used with the other conditions identical with the SPGR. The signal-to-noise ratios of the images were calculated by using the standard deviation of the air backgound[4]. In each imaging sequence, 5 measurements were made to statistically evaluate the results.

The influence of the Bluetooth communication to the tracking system was then examined under the conditions, C1-C3. The tracking sensor was placed at the positions, P1-P3 shown in Figure 3. The location data (x_i, y_i, z_i) were acquired with an interval of 63 milliseconds and for 30-60 seconds. Thus the average of the location data (x, y, z) were calculated to evaluate the tracking accuracy.

RESULTS and DISCUSSION The averaged values of the image intensities in an ROI, 20.1 x 20.1mm in the first examination are shown in Figure 4. Based on the double-sided Welch's t-test, the differences of the averaged image intensities between C2 and C1 as well as C3 and C1were not significant ($p < 0.05$).

The Euclidean distances between the locations under the C1 and other conditions are shown in Table 1. The maximum error was 0.85mm and was observed at the location P3 when the controller was on the shelf. The errors were smaller than 0.2mm except for the location P3. From this, the inadequate fixing of the sensor was capable of causing the maximum error.

CONCLUSION No significant signal-to-noise ratio reduction was recognized by operating the control device near the magnet in the shield room. Although a slight error in the location estimation was observed for the gradient field sensor, the overall performance of the sensor was not affected by the control device. The resultant image process control was successful as shown in Figure 1 indicating that the image manipulation obviously becomes smooth and intuitive when compared with the mouse/keyboard operation. Thus the control device can be dedicated for the intuitive image process control of the MR-endoscope system. This also indicates that the use of an acceleration sensor in an interventional MR suite is possible.

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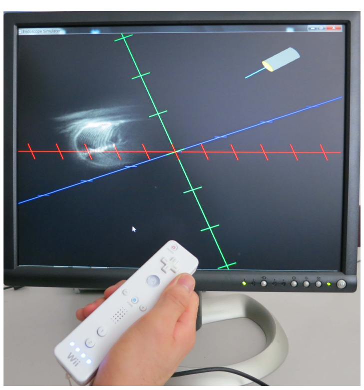

Figure 1 Demonstration of rotating MR volume data by using the controller. MR volume data were porcine gastric wall.

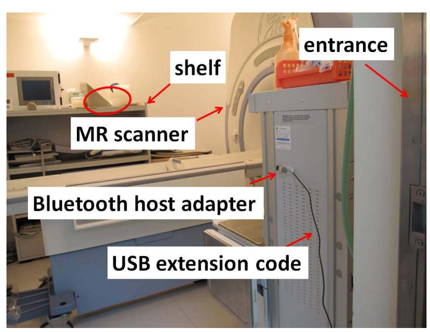

Figure 2 Condition of MR room.
Red circle is the location of setting the controller

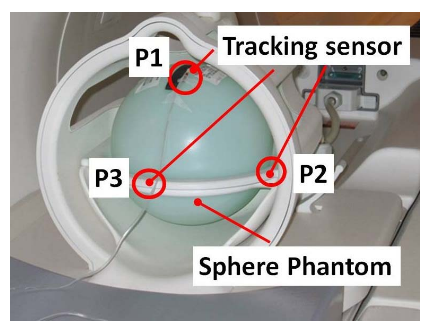

Figure 3 Location of tracking sensors.
Tracking sensor was stuck in the tape.

Table 1 Error of location between C1 and other conditions

	Location Error (mm)	
	C2	C3
P1	0.18	0.07
P2	0.15	0.20
P3	0.85	0.53

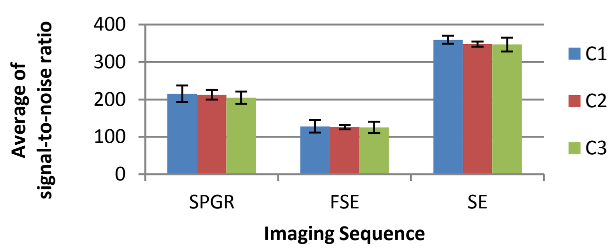

Figure 4 Average of signal-to-noise ratio under the C1-C3