An Optical and Electromagnetic Hybrid Tracking System for MR Image Guided Interventional Procedures

S. Morikawa[1], H. A. Haque[2], S. Naka[3], K. Murakami[3], Y. Kurumi[3], T. Tani[3], and T. Inubushi[1]

[1]Biomedical MR Science Center, Shiga University of Medical Science, Ohtsu, Shiga, Japan, [2]GE Yokogawa Medical System, Hino, Tokyo, Japan, [3]Department of Surgery, Shiga University of Medical Science, Ohtsu, Shiga, Japan

INTRODUCTION

In MR guided interventional procedures, image planes are required to include the needle path accurately. For the purpose, an optical or electromagnetic tracking system has been used. The optical tracking system precisely works in the strong magnetic fields, but line of sight must be maintained. Surgical procedure and instruments easily obstruct the light path and applicable angles are limited. An electromagnetic tracking system, which utilizes gradient pulses during data collection, can be used in any directions and even in the covered area, but it requires continuous MR image acquisitions to obtain the latest information. The accuracy of its information is decreasing at magnet center, where the changes in the magnetic strength by gradients are small, and at the periphery, where the gradients are not linear. They have advantages and disadvantages. To take advantages of two sensor systems complementarily, we have developed a hybrid tracking system of them for MR guided interventional procedures with an open configuration MR system.

MATERIALS AND METHODS

All MR data were collected on a 0.5 T SIGNA SP/i system (GE Medical Systems, Milwaukee, WI). An optical tracking system, FlashPoint Model 5000 (IGT, Boulder, CO), was integrated in this system. An electromagnetic tracking system, EndoScout (Robin Medical, Baltimore, MD)[1)], was also installed in this MR system for the interactive scan plane control. We made a hybrid hand piece combining both sensors (Fig. 1). We have developed our own navigation software with a capability to control MR scanner, which shows real-time MR images of alternate 2 perpendicular planes and reformatted images in the corresponding planes from preoperative 3D data[2)]. In a client-server architecture, 4 server applications were prepared. Two servers were used to receive data from 2 tracking systems, one was used for MR scanner control and the last one was used for image transfer. The software continuously receives the information of the position, orientation and status of both sensors every 100 ms. The different offsets from two sensor systems were calibrated and compensated in this software. The optical tracking system was used as a primary sensor, but when it is blocked, the information of the electromagnetic sensor was used for image plane control.

RESULTS AND DISCUSSION

The hybrid tracking system was found to be very useful. Even if the optical sensor was blocked, the electromagnetic sensor seamlessly supported the interactive MR image plane control. Surgeons could perform interventional procedures without taking care of the line of sight and could approach the target in any directions. It was shown to surgeons on the in-bore display, which sensor is active and controls the image planes (Fig. 2). The function of calibration between the two sensor systems by the software was quite helpful. We could easily make and utilize various kinds of hybrid handpieces without specific tool files for EndoScout system. We have already developed several kinds of hybrid handpieces for a manipulator to assist microwave ablation of liver tumors (Fig. 3). In this procedure, lateral approach is frequently required depending on the tumor locations and, in such a situation, the line of sight of the LEDs is easily obstructed. At present, the optical tracking system is used as a primary sensor, but as shown in Fig. 3, the electromagnetic sensor can be placed close to the target in some cases. Shorter offset to the target is advantageous for the accurate navigation. More intelligent algorism to select the sensor system will be developed, when both sensors are available.

In conclusion, we have developed an optical and electromagnetic hybrid tracking system and an application to utilize the information from 2 sensors. The hybrid system took advantages of two sensors complementarily and enabled seamless navigation in real-time MR image guided interventional procedures.

REFERENCES

1. Nevo E, Roth A, Hushek S. ISMRM 10: 334, 2002.
2. Sato K, Morikawa S, Inubushi T, et al. Magn Reson Med Sci 4: 89-94, 2005.

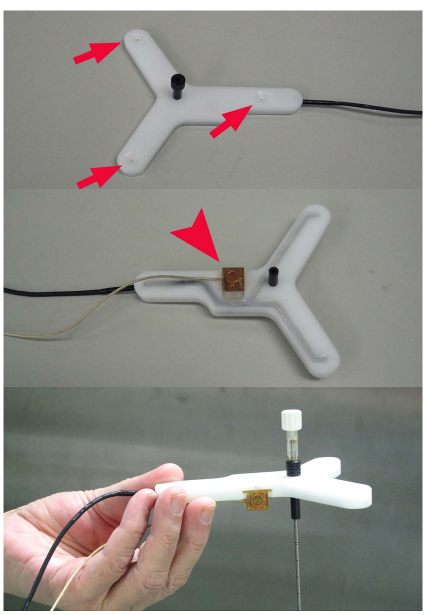

Fig. 1 A handpiece for an optical and electro-magnetic hybrid tracking system. Three LEDs (arrows) for optical tracking are placed on the upper surface. A cube sensor (arrow head) for electromagnetic tracking is fixed on the underside.

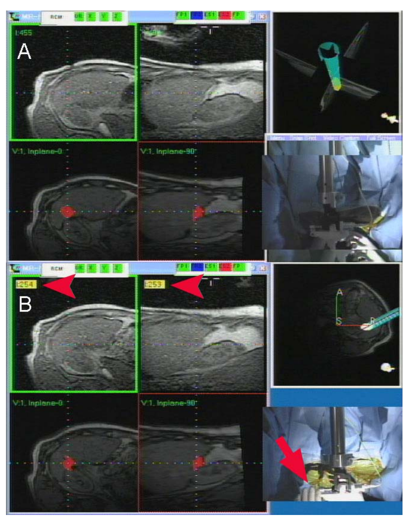

Fig. 2 Displays of our navigation software. Real-time MR images of inplane 0 and 90 (upper left 2 windows), and corresponding reformatted images from 3D data (lower left 2 windows) are shown. (A) image planes are controlled by the optical tracking system. (B) One LED is blocked by the hand (arrow). Image planes are controlled by the electromagnetic tracking, which is shown to the surgeons by inverting image numbers (arrow head).

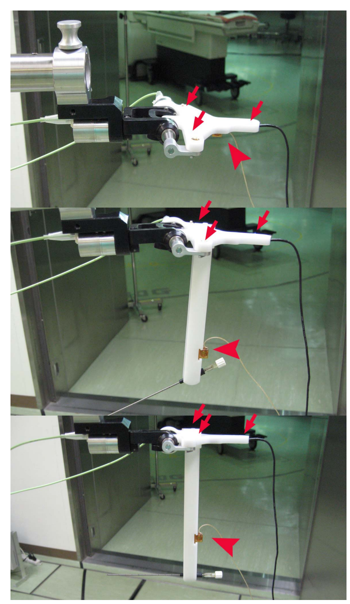

Fig. 3 Hybrid hand pieces of a manipulator for MR-guided micro-wave ablation of liver tumors. Three LEDs (arrows) for optical tracking and a cube sensor (arrow head) for electro-magnetic tracking are combined.