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Laparoscopic sigmoidectomy Surgery training system using AR follow-up experience of real human surgery

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Abstract

In our learning system (OITORE Advance), high learning effect was confirmed by using teaching materials using porcine intestines. However, because the environment inside the abdominal cavity is different between pigs and people, there are scenes with different surgical procedures and surgical skills. Therefore, not all the learned skills are applied in human surgery. Therefore, in this paper we changed teaching materials from pig to human and adjusted the system accordingly.

CCS Concepts

• ***Hardware*** →Pseudo-Haptics, Stereoscopic vision, Laparoscopic surgery training system, View sharing system

1. Introduction

Laparoscopic surgery is performed by inserting a camera and forceps into the abdominal cavity. It is less invasive than laparotomy surgery. This method minimize patient damage. This is one of the main reasons that the laparoscopic surgery is well-known in the gastroenterological surgery.

However, as compared to the open surgery, the doctors need high skills to perform this surgery. In laparoscopic surgery, the insertion port for the forceps acts like a fulcrum and the surgeon views the abdominal cavity through a monitor. Therefore, surgeons must consider direction and scale conversion from eye to hand.

Therefore, it requires a long time to learn the techniques of laparoscopic surgery. In general, the simulated affected part that a dry box is used for elementary training. However, self-education training not only takes time but gets a bad habit. Therefore, we thought that the operations skills can be transmitted by superimposing a recorded video of an expert's forceps operation into a learners' forceps video at the time of laparoscopic training.

We have already developed the training system equipment for the re-experience of the expert's forceps movement with the dry box, called "OITORE" [DHH*13]. In these systems, we took advantage of the characteristics that the surgical images are "shared" by the monitor in endoscopic surgery. By this approach, the learners could accept the benefits of the non-verbal skill transfer through tracing the expert's forceps motion.

2. Re-experience training system using actual surgery, "OITORE Advance"

The important skills which the intermediate should master is not the training for the separate operation but for proceeding a series of operations. As proceeding the surgery, the surgical site is moved further inside. Inevitably, the endoscopic camera needs to move further inside following a surgical process. In this situation, it is very difficult to superim-pose a trainee's forceps on the expert's ones on the presu-position that a trainee keeps the correct posture. So, we developed new system which is able to superimpose the video of the expert's forceps on the video of the trainee's forceps even if the endoscopic camera moves (Figure.1). We call this system "OITORE Advance" and it is placed as shown in Figure.2

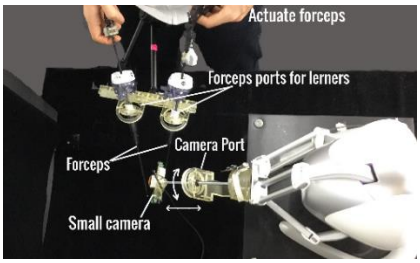

Figure 1: Training equipment that simulates the motion of the endscope.

We used pig sigmoidectomy surgery as a teaching animation of OITORE Advance we made in the past [NKYH17]. It demonstrated that the trainee who was trained using this device efficiently has surgical skills by evaluating the expert's skills at the animal laboratory.The result is shown in Figure 3. With the evaluation and scoring based on the method of the skill qualification system of JAPAN SOCIETY FOR ENDOSCOPIC SURGERY, the trainees who trained by OITORE Advance tended to be higher in the score of surgical technique evaluation. Especially, in relation to the items of the smoothness of operation progress and the speed · the visibility of organ in operation field · the correct identification of blood vessels and appropriate treatment, the trained group has higher score.

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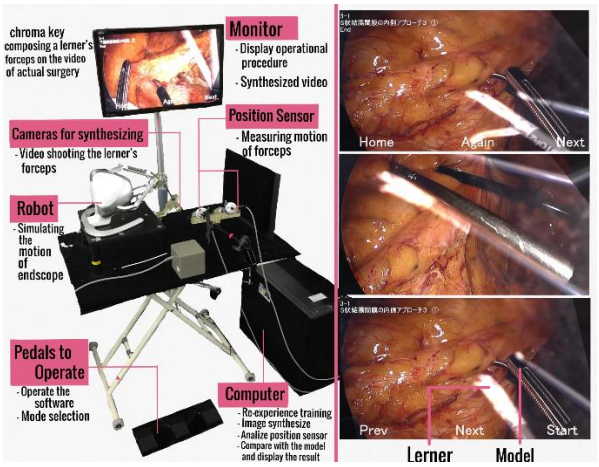

Figure 2: A view of "OITORE Advance". ;Pictures on the right are views of the training software. Superposing the expert's video and the lerners' perceps on it.

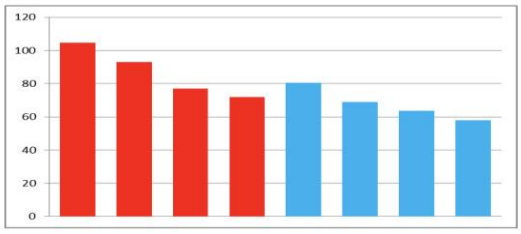

Figure 3: Trained group by OITORE Advance (Red, 4 persons) and the control group (Blue, 4 persons). Comparison of point about operation technique. Three experts scored each trainees out of 50 points.

3. "OITORE Advance" using materials of human laparoscopic sigmoidectomy

We confirmed the effectiveness of OITORE Advance using pig sigmoidectomy surgery as teaching animation. However, in pigs and humans, built-in and blood vessel structure and arrangement are different, so it is a different teaching material from actual surgery. For example, even with the same sigmoidectomy, procedures of lymph node dissection are different because the arrangement of lymph nodes is different between pigs and humans. Also, because the space in the peritoneal space is different, the spatial arrangement of internal organs differs. It is important for the laparoscopic training system to accurately learn the procedure of laparoscopic surgical techniques treatment and spacifically for humans. Based on the effects of pigs and the indications by doctors, we made educational materials for human sigmoid colon surgery after undergoing ethical review by the medical department of Kyoto University Hospital. In the measurement, 3D sensors used in engineering such as optitrack were not approved for use from an ethical point of view. Therefore, it is necessary to use medical equipment approved by Ministry of Health, Labor and Welfare of Japan. We diverted the system for external brain.

Figure 4: Data measurement of sigmoidectomy using position measuring system for brain surgery made by BLAINLAB.

As mentioned above, the space inside the abdominal cavity of humans is wider than that of pigs, so in the system of the past OITORE Advance, the operation area exceeded the range of motion of the robot. The other hand, although the laparoscope used when on a pig as teaching material was a perspective camera in which the position of the lens is inclined from the axis of the laparoscope, in this human teaching material, the axis of the laparoscope and the optical axis of the camera. Cameras with direct view, which coincide with each other, were used. By changing the camera from the perspective view to the direct view, the range of motion required for the robot has further expanded. In order to solve these problems, the scene where the laparoscope is inserted more than a certain amount is enlarged by appropriately enlarging the field of view of the camera, and the treatment area is controlled to fit in the range of motion of the robot.

4. The future plan

As a future schedule, we will conduct verification experiments using cadaver surgery. We will divide the four resident doctors scheduled to undergo cadaver surgery into two groups with and without machine, analyze skills, and show the usefulness of the machine.

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References

[DHH*13]

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https://www.youtube.com/watch?v=iDKS4 HqKDvA

[NKYH17]

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