Institute for High Dimensional Medical Imaging

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General Summary

The goal of our research is to develop new imaging systems that can be applied to clinical medicine now and in the future. High-dimensional, i.e., 3-dimensional (3D) and 4-dimensional (4D), imaging techniques have enabled noninvasive, realistic, uninhibited, and accurate observations of human spatial structures and their dynamics. The availability of real-time imaging using high-performance computers and medical virtual reality systems has expanded the possibilities for diagnosis, treatment, surgery, and medical education. The Institute for High Dimensional Medical Imaging has, therefore, established a system that facilitates cooperative research and development with international researchers and organizations.

Research Activities

Clinical application of high-definition, real-time medical imaging
We are performing research on the development of medical high-definition imaging technology and its clinical application using functional and morphological data obtained with X-ray computed tomography (CT) and magnetic resonance imaging.
This year, we developed a system that can evaluate a physician's diagnosis and treatment of a patient with medial compartment osteoarthritis of varus knee. The system can analyze the trajectory of a patient's knee adduction moment and the center of pressure on the rear foot during walking.
This research is being performed by departments of our university in collaboration with Osaka University, Tsurumi University, and Mayo Clinic (Rochester, MN, USA).

Development of an endoscopic surgical robot system
We are developing an endoscopic surgical robot system that can be used to perform natural orifice translumenal endoscopic surgery and single-port surgery. Robotic instruments enter the abdominal cavity orally or through a single incision in the navel and are used to perform surgery on the abdominal organs. Last year, we improved the robot arms so that they could have more freedom of movement. This year we improved them so that they could conduct more complicated tasks. We also isolated the movements of the camera, which are the eyes of the robot, so that the robot's upper limb can perform movements closer to that of the humans.
This research is being performed in collaboration with Kyushu University's Department of Surgery.

Development of a simulator for the endoscopic surgical robot system
To perform surgery with the surgical robot system described above, the operator requires

training because the operative method differs greatly from that of conventional surgery. Therefore, we are developing a simulator system for animal experiments that has the same functions as the actual surgical robot system. This year, we developed a basic training system to control the robot arms for beginner operators who are not familiar with using the robot by setting up tasks in a virtual reality environment. The tasks consist of stages of different levels. We also improved the training system for using organ models by enabling the system to record and save all processes during training. After the training, the operator can observe and analyze the changes of the operational field during training in 4D from any viewpoint.
This research is being performed in collaboration with Kyushu University's Department of Surgery.

Development of an image-guided surgery system
We are developing a surgical navigation system that can perform data fusion for 3D images of the interior structures of veins, nerves, or tumors which cannot be seen with the naked eye when surgery is performed under the skin or within organs. This year, in a collaborative study with our university's Department of Otorhinolaryngology, we performed stereoendoscopic sinus surgery 3 times. This year we also developed a new pointer-based navigation system. Combining the use of this new navigation system with the endoscope-based navigation system, the operator can grasp the 3D structure of the operational field more intuitively. For the navigation system under development in collaboration with the Department of Surgery, we have developed a system that uses a laparoscope with an appropriate shape for capturing images of the operative field during laparotomy. We plan to apply this system clinically in the near future.

Application of high-definition medical image analysis to forensic medicine
By applying technology that we have developed for analyzing high-definition medical images, we are analyzing X-ray CT data sets of crime victims with the aim of developing new methods for future criminal investigations and for establishing new methods for creating court documents. This year, we have improved the system to allow better 3D analysis of a victim's injuries. With this system, we have analyzed the position, depth, and angle of a victim's wounds in 3D using X-ray CT data sets from cases of murder and attempted murder at the request of the Tokyo District Prosecutor's Office.
This research was performed in collaboration with our university's Department of Forensic Medicine, the Tokyo District Prosecutor's Office, and the Metropolitan Police Department.

Publications

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