Research Center for Medical Sciences
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 with 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.

We are developing a 4D motion system for analyzing human activities, such as the motions of the whole body. The system is driven by motion data obtained from anatomical and skeletal muscle models reconstructed from X-ray CT data sets. In this year, the evaluation of the deformation of the skeletal muscle model using MRI was performed together with the Department of Radiation in the development of a four-dimensional human body model capable of deforming soft tissues (skin, abdominal organs, skeletal muscles, vasculature, etc.) in whole body movements. It is difficult for MRI currently used in clinical practice to measure regions having certain capacity as volume data like MDCT at high speed. Therefore, we developed equipment, which the participant can repeat a certain action in a stable manner with the similar load applied as walking in the gantry. We also developed a device capable of synchronizing the motion of participants and MRI imaging, and conducted a clinical trial by examining a sequence capable of photographing in a large spatial resolution of a wide region of certain extent. We also continue to develop a system that predicts and visualizes future growth of children using multiple X-ray CT data measured in the past.

From this year, we began developing a three-dimensional shape evaluation method of outside nose cartilage with the Department of Plastic and Reconstructive Surgery. For outside nasal cartilage, which is said to be difficult to detect by normal image examination, we examined imaging technique using X-ray CT and MRI with the Department of Radiation. This research aims not only to evaluate the cartilage shape but also to develop

a system that performs surgical planning and surgical simulation based on the obtained results.

Development of endoscopic surgical robot system
We are developing an endoscopic surgical robot system that can be used to perform natural orifice transluminal endoscopic surgery (NOTES). Robotic instruments enter the abdominal cavity orally and are used to perform surgery on the abdominal organs. Following our research from the previous year, this year, we are refining the driving mechanism of the over tube flexing mechanism to maintain the posture in the abdomen of the robot.
In addition, in development of a multi-view camera system suitable for endoscopic surgery and robot surgery, we were able to acquire patents based on research results.

Development of a surgical simulator for various surgical techniques
We are developing a simulator that can deal with various surgeries, such as laparotomy and endoscopic surgery, using preoperative X-ray CT data of a patient.
This year, we developed a system that reflects the results of preoperative surgical simulation in intraoperative navigation and examined its usefulness in clinical trials of navigation surgery as described later. Moreover, in the development we are conducting from last year, of a 4-dimensional image display system to real space where the surgeon can intuitively grasp the anatomy structure, the research proposal planned based on this basic experiment was chosen for JSPS Grant-In-Aid for Scientific Research (A).

Development of an image-guided surgery system
We are developing a system that can display blood vessels and tumors at the back of the surgical field in the form of 3D geometric models in multiple layers on the surgical field screen. Such improvements will make the navigation system more intuitive. This year the Department of Surgery and the Department of Otorhinolaryngology again jointly performed navigation surgery in the high-tech navigation operating room of Daisan Hospital as a semiroutine procedure. Especially, in this year, research results on intraoperative navigation system using tablet PC which we are developing with the Department of Surgery, won a prize at an international conference.
In addition, from this year, we started basic experiments for development of intraoperative navigation system with the Department of Obstetrics and Gynecology. Because the gynecologic and gynecological field is an area in which intraoperative navigation has been rarely performed, we examined the selection of parts and blood vessels necessary for navigation and the presentation method by basic experiments.

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. As we did last year, this year we carried out 3D analyses of the position, depth, and angle of the attempted-murder victim's injuries using the victim's

X-ray CT data set.

Publications

Kimura T, Kubota M, Taguchi T, Suzuki N, Hattori A, Marumo K. Evaluation of first-ray mobility in patients with hallux valgus using weight-bearing CT and a 3D analysis system: A comparison with normal feet. *J Bone Joint Surg.* 2017 Feb; **99:** 247-55.