Research Center for Medical Sciences
Institute for High Dimensional Medical Imaging

Naoki Suzuki, *Professor*　　Asaki Hattori, *Associate Professor*

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 (MRI).

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. Continuing from last year, we measured with MRI the upper and lower limbs of a subject in motion and compared the 4D changes of the skeletal muscle with that of a 4D human model in development. We also evaluated these comparisons. In addition, we have started developing a method to stably measure with MRI the internal structure of humans that change over months and years.

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. In the project to develop an overtube to control the posture of a robot in the abdominal cavity, we are developing a drive mechanism with a shape memory alloy so that the needed power and speed can be obtained for a robot to hold its posture and change directions.

Development of a surgical simulator for various surgical techniques

We are developing a simulator that can deal with various types of surgery, such as laparotomy and endoscopic surgery, using preoperative X-ray CT data of a patient. Last year

we started to develop a simulation system that reproduces the trajectory of surgical instruments and evaluates surgical techniques. This year we started evaluation testing with phantoms and are analyzing the differences in techniques depending on whether the operator has experience. With regards to a 4D image display system for real space, which is a research subject supported by a Japan Society for the Promotion of Science Grant-In-Aid for Scientific Research (A) in its second year of development, we are evaluating and identifying problems using an experimental machine to improve the system.

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 again jointly performed navigation surgery in the high-technology navigation operating room of Daisan Hospital as a semiroutine procedure. This year we have developed a new function of the system which warns the operator via voice and images how far the surgical instrument's tip is located from the resected surface planned before the operation. We evaluated the function with a phantom. In addition, in laparoscopic surgery for gynecology, we continue to develop a navigation system that does not use preoperative X-ray CT or MRI data.

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. Last year, at the request of the Ministry of the Environment, we started to analyze the cause of death of nationally protected species of animals in traffic accidents. Therefore, we are also developing an analysis method with X-ray CT data obtained from the animals after the accident.

Publications

Yasuda J, Okamoto T, Onda S, Futagawa Y, Yanaga K, Suzuki N, Hattori A. Novel navigation system by augmented reality technology using a tablet PC for hepatobiliary and pancreatic surgery. *International Journal of Medical Robotics and Computer Assisted Surgery.* 2018; **14:** e1921.