# 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.

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. Following our research from previous year, this year, the measurement 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. We expanded the target parts to include lower thigh and upper limb, and measured the changes in the skeletal muscle for each part and evaluated the 4D human body model. 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.

*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. Continuing from the last year, we are improving the structure and material of the overtube drive mechanism with a bending mechanism for the robot to maintain posture in the abdominal cavity.

*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.
In this year, as a further integration of preoperative surgical simulation and intraoperative navigation system, we began to develop a system where the trajectory of surgical instruments recorded in the clinical trial of navigation surgery (described later) is reproduced on the surgical simulation system so that surgery can be evaluated postoperatively. Also in this year's development of a 4D image display system for real space which was chosen as a research subject of JSPA Grant-In-Aid for Scientific Research (A), we designed and fabricated the mechanisms of elemental technologies an evaluated them.

*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-tech navigation operating room of Daisan Hospital as a semiroutine procedure. In this year, in order to make effective use of the navigation system during surgery, we started to develop a system in which the tip position of the surgical instrument used for resection is constantly measured, and the distance to the planned resected plane and the region of the margin from the tumor is provided as information to the surgeon. In addition, we also started developing the function to record the tip position and direction of the surgical instrument and reproduce it after the surgery. We are also continuing to develop navigation systems for endoscopic surgery in the field of obstetrics and gynecology.

*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. From the current year, we also began analyzing the cause of traffic accident death of animals designated as national natural treasure at the request of Ministry of the Environment, using analysis techniques we have developed through our research.

## Publications

***Kimura T, Kubota M, Suzuki N, Hattori A, Marumo K.*** Comparison of Intercuneiform 1-2 Joint Mobility Between Hallux Valgus and Normal Feet Using Weightbearing Computed Tomography and 3-Dimensional Analysis. *Foot Ankle Int.* 2018; **39:** 355-60.