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

1. Clinical application of high dimensional medical imaging with virtual reality techniques

We are developing technology for high dimensional medical imaging using biological and morphological data sets from X-ray computed tomography (CT) and magnetic resonance imaging (MRI). In our research we study the visualization of 4D-CT data sets and develop clinically applicable methods of 3D and 4D image data management and visualization. This research is performed in collaboration with such institutions as Kyushu University, Osaka University, Tsurumi University, and the Mayo Clinic (Rochester, MN, USA).

2. Surgery navigation system development

We are developing a navigation system that can overlay the 3D images of the internal structure of the body onto the surgical field. We have developed navigation systems for robotic surgery systems and have designed and built a high-tech navigation operating room at Daisan Hospital. This year, we performed 2 navigation surgeries in this operating room. In joint research with the department of otorhinolaryngology, we examined the use of our navigation system for microscope surgery and stereoendoscopic surgery.

3. Endoscopic robot surgery system development

We are developing an endoscopic robot surgery system that can be used to perform natural orifice transluminal endoscopic surgery, which is a technique for operating on abdominal organ via the mouth. We have developed endoscopic surgery robots that enable the surgeon to more freely perform surgical manipulations in the gastrointestinal tract using a pair of forceps-type manipulators. This year, we developed a robotic telesurgery system that allows a surgeon to perform an operation from a remote location by controlling a robot via a computer network. After a preliminary experiment, we performed a robotic telesurgery experiment with a soft cadaver via a high-speed computer network between Japan and Thailand. In the experiment, a robot that we controlled from Japan was used to excise a lymph node from the abdominal cavity of soft cadaver with a digestive tract cancer in Thailand. We are collaborating with Kyushu University on this project.

4. Surgery simulation system development for robotic surgery

An operation using the robotic surgery system described above is very different from a normal operation and requires advanced training to perform. Therefore, we are developing a surgical simulation system that allows the same surgical procedure to be performed in a virtual space with an internal organ model constructed from X-ray CT and MRI data sets of a patient. This year we constructed a soft-tissue model of a channel that reaches the stomach for training. Using a force-feedback device, the surgeon operates a forceps-shaped robot arm in virtual space and can change the shape of the gastric wall in real time.

5. Development of a visualization and analysis system for temporomandibular joint activity

We are developing a 4D system for real-time quantitative analysis of the movements of the lower jaw. First, we reconstructed a 3D skeletal model using X-ray CT data of the upper and lower jaws of a patient with a temporomandibular joint disorder. Second, we activated the skeletal model using data of the patient's jaw movements. This year we performed an analysis in virtual space, created a plaster model, activated it with a multiple-joint robot, and were able to analyze the jaw movements in real space. By analyzing both the virtual and real spaces, we could exploit the advantages of both spaces and could more effectively establish diagnoses and create treatment plans. We are performing this research project in collaboration with Tsurumi University.

Publications

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Ikawa T*[1], *Ogawa T*[1], *Shigeta Y*[1], *Hirabayashi R*[1], *Fukushima S*[1] ([1]*Tsurumi Univ), Otake Y, Hattori A, Suzuki N. Evaluation of the simulation robot for mandibular movements with the patient-specific 3-dimensional plaster model and mandibular movement data: Clinical application of the physical simulation robot. *Medicine Meets Virtual Reality* 2008; **16:** 183-8.

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Reviews

Hattori A, Suzuki N, Suzuki S, Otake Y. Development of an endocsopic robot system for NOTES (in Japanese). *Nihon Computer Geka Gakkaishi* 2007; **9:** 79-84.