nakajima.bmi@tmd.ac.jp

Department of Biomedical Information

Professor Yoshikazu Nakajima

Artificial intelligence and numerical computation for medicine

1. **High-dimensional and multidisciplinary medical imaging**
2. **Artificial intelligence (AI) and brain-machine interface (BMI)**
3. **Intuitive surgical navigation with augmented reality**
4. **Surgical assistant devices using stiffness-tunable mechanism**
5. **Autonomously networking computer agents for medical applications**

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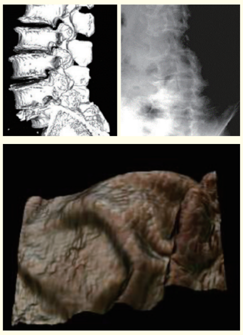
The mission of Nakajima Laboratory is to bring the power of medical computation servers and surgical assistance systems into clinical settings. The methods developed by our group can provide artificial-intelligence (AI)-based integration of multi-modal medical data. These technologies provide intelligence that is useful to analyze, simulate, plan and assist surgeries. In addition, we have developed an internet-of-things (IoT) platform that can integrate such AI computers with sensors and surgical robots. These developments can truly lead the computerization of medicine. Our systems have been introduced into practical surgery routines in several hospitals. They have reported using our systems in more than 200 successful clinical cases.

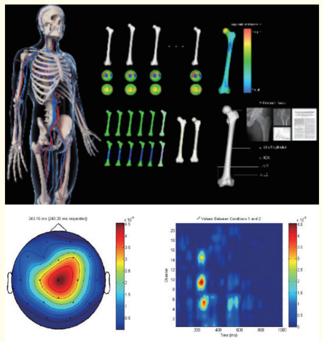
High-dimensional and multidisciplinary integration of medical data

The combination of feature extraction and correspondence was applied to different medical modalities to provide high-dimensional and multidisciplinary data. We were able to integrate volumes of data from CT, MR and PET images, pre- and intra-operative measurements, the patient's measurements and general numerical knowledge of the human body. These data were summarized to create a human body model that was statistically average in shape and variations, and that also could be reshaped. The human body model was analyzed by an AI computer and each part of it was labeled to link to numerous quantitative data and knowledge databases.



Artificial-intelligence (AI)-based medical data analysis and brain-machine interface (BMI)

Artificial intelligence (AI) was applied to process medical tasks. A deep-learning neural network labeled anatomical parts of organs on a patient's images and segmented them to each organ to analyze quantitatively. As another approach to brain science, brain signal patterns were measured and analyzed with respect to external stimulation of vision and thoughts. These studies gave some hints for the design of AI algorithms. They were also applied to designing the interfaces connecting the brain and computers.



Autonomously organizing computer agents and an internet-of-things (IoT) platform for medical systems

Agents of various data and processors were unmewed on the network. The agents asked questions of one another, checked connection possibilities, introduced themselves to one another, and then sent data to one another. Each agent was embedded into a sensor, a database interface, or a search engine of the internet. When these agents connected autonomously, the networks performed powerfully on data processing and analyzing compared with connection-fixed neural networks.

Surgical-assistance navigators and robots

Augmented reality and laser projection mapping were applied to visualize quantitative surgical data intuitively. To achieve high accuracy, our device captured the organ's shape and tracked its deformation. After compensating for the deformation in data space, surgical plans were projected onto the organ surface directly with a laser projector. In addition, some compact surgical robots were developed and tested to achieve more accurate surgeries. The deformation tracking also worked for navigating these robots.