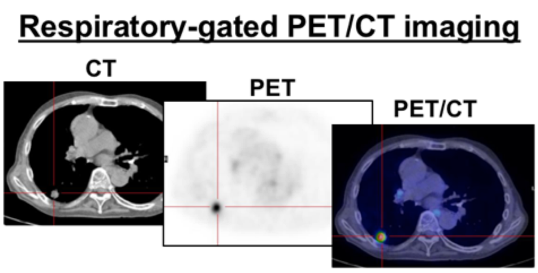
Nuclear Medicine Physics and Health Physics

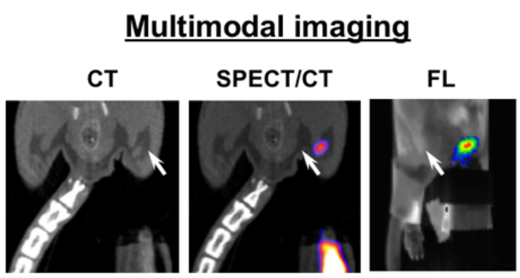
Supervisors: Professor Kazumasa INOUE, Associate Professor Masaru TAKABATAKE

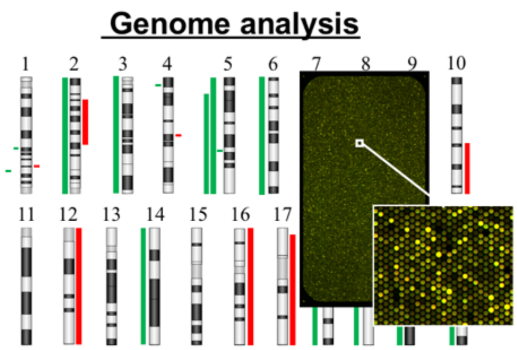
The Nuclear Medicine Physics and Health Physics Field at Tokyo Metropolitan University focuses on the development of novel nuclear medicine imaging techniques in clinical and small animal SPECT and PET, including SPECT/CT, PET/CT and PET/MRI multimodal imaging techniques, and development of clinical image assessment techniques. Our field also focuses on identifying environmental radiation from natural and artificial radionuclides including naturally occurring high level environmental radiation areas and areas contaminated from the nuclear accident of the Fukushima Daiichi Nuclear Power Plant; development of novel radiation dosimeters using artificial intelligence (AI); and identification of the mechanisms of health effects due to chronic low dose rate radiation exposure by using genome analysis. Besides these research activities, our main activities include conducting clinical training and educating radiological technologists and medical physicists at major hospitals in Japan.

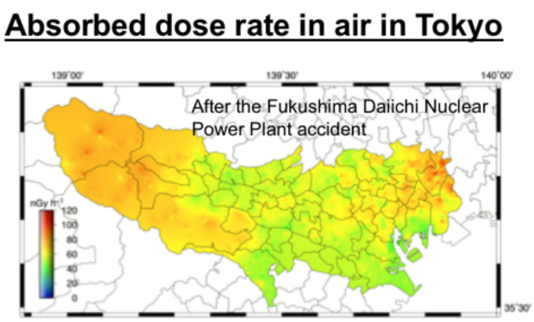
We have had about 100 publications appear in academic journals including the *Journal of Nuclear Medicine*, *Radiation research, Marine Pollution Bulletin, Scientific Reports* and *PLOS ONE*, and we have received over 24 honors from professional societies for our contributions to nuclear medicine and health physics. More detailed information about supervisors is "https://researchmap.jp/kzminoue". Our supervised students have received 25 doctoral degrees and 59 master's degrees, and all of them are active in the field of clinical research and education as of FY 2022. We also have attracted outstanding foreign students from Thailand, Vietnam, India, Sri Lanka and Egypt over the years. We are always recruiting highly motivated research students.

Major collaborative research and education institutes: National Institutes for Quantum and Radiological Science and Technology (Japan), Institute for Environmental Sciences (Japan), National Cancer Center Hospital and Hospital East (Japan), Tokushima University (Japan), Kagawa University (Japan), Harvard Medical School (USA), Georgetown University (USA), Pondicherry University (India), N.B.H. Garhwal University (India), Chulalongkorn University (Thailand), Chiang Mai University (Thailand), Ho Chi Minh City Medical, Pharmacy University (Vietnam) and Cho Ray Hospital (Vietnam).







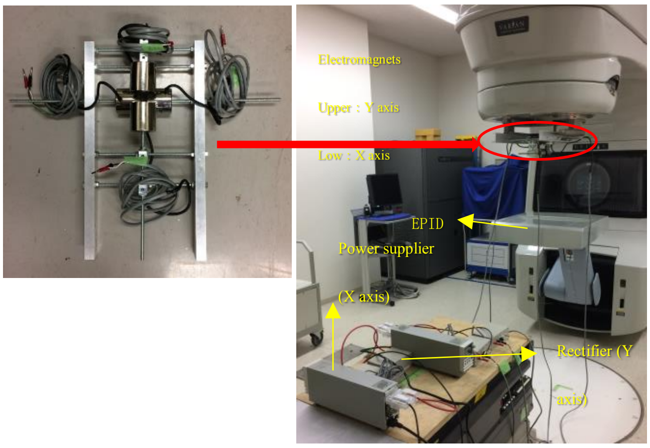


Radiation Oncology Physics

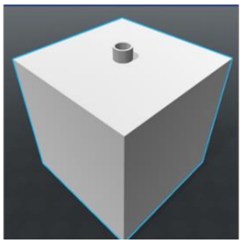
Faculty in charge: Atsushi Myojoyama

As research related to radiation therapy, we research and develop new devices for high-precision radiation therapy, high-energy imaging by X-rays and electron beams, automatic patient authentication for safe radiation therapy. We accomplish those themes with knowledge of radiation physics and programming.

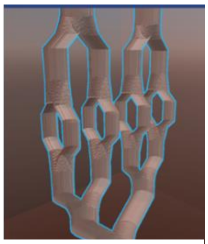
- High-quality MV CBCT image reconstruction
- New imaging method using linear accelerator
- Development of new blood vessel phantom for multi-modality
- Improvement of quality of portal images using high-energy X-rays
- Development of fast Monte Carlo simulations to calculate dose distribution



Development of image acquisition device by bending of electron beam using electromagnets

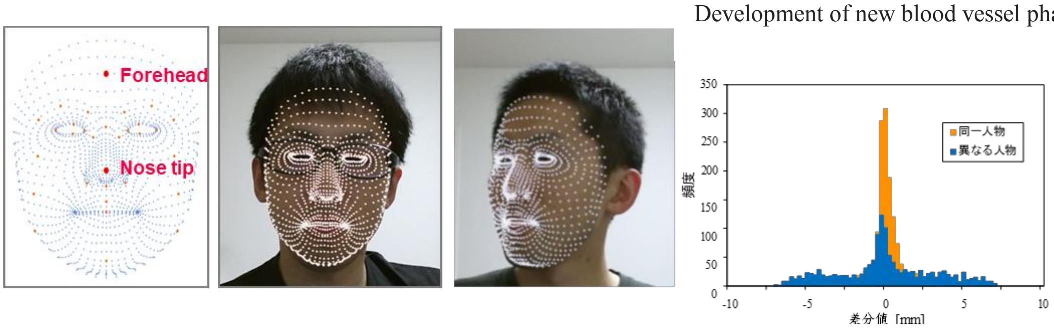


3D phantom model



blood vessel model

Development of new blood vessel phantom



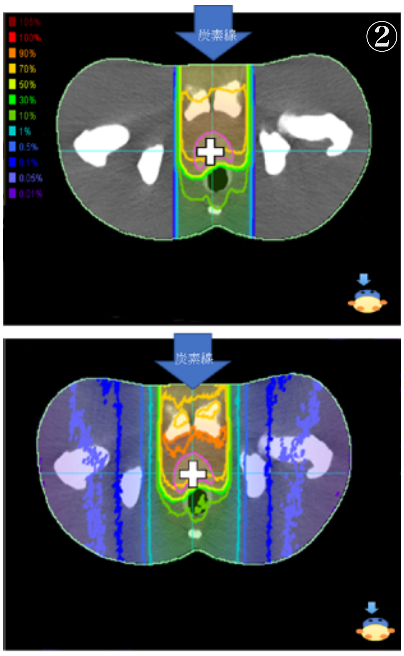
Automated patient authentication by face authentication using Kinect

Radiation Oncology Physics

TOKYO METROPOLITAN UNIVERSITY
東京都立大学

Supervisor: Weishan Chang

We provide education and research on issues related to dose calculation / measurement and quality assurance related to the latest technology for radiotherapy of photon and heavy charged particle.



Laboratory Policies

Our lab strives to develop the ability to discover and solve potential problems.
Anyone who wants to become a medical physicist in the future is welcome.

Current Research Topic in our lab.

- Development of audit dosimetry system using passive dosimeters for proton therapy
- Tool development for retrospective analysis in heavy charged particle radiotherapy
- Absorbed dose measurement in carbon–ion radiotherapy.
- Evaluation of time delay for IGRT using MR guided ^{60}Co unit.
- Feasibility of polymer gel dosimetry in BNCT
- Direct energy spectrum measurement of a LINAC using NaI scintillator

Figure Legend

① LINAC. You can use this linac to do your research.
② Comparison of dose distribution between TPS (UP) and Monte Carlo simulation(DOWN).
③ Organ dose measurement using

Medical Radiation Measurement

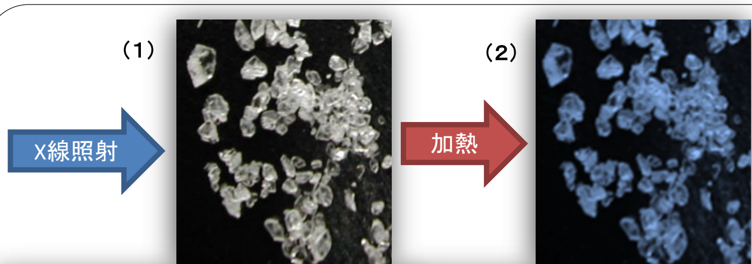
Faculty in charge: Kiyomitsu Shinsho

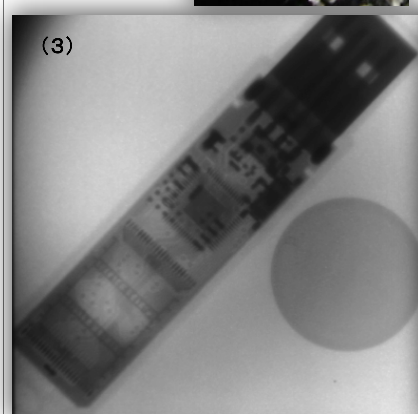
Research laboratory policies: We place importance on developing the ability to independently solve problems. You should try to tackle questions that no one can answer. In our research laboratory, you can gain experience in the synthesis of phosphors that are sensitive to radiation, chemical analysis, optical measurement, analysis, and even the development of measurement systems.

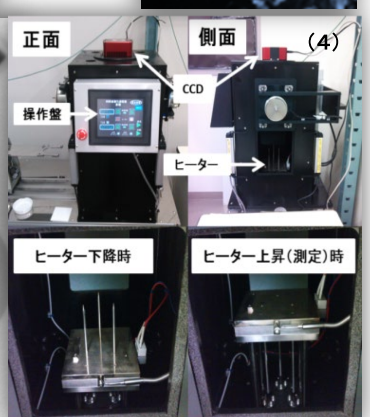
Research details: We develop new radiation measurement devices, making use of a classical phenomenon called **"thermoluminescence(TL)"** and **"optically-stimulated luminescence(OSL)"** conduct research on its mechanism.

Current major research projects

1. Studies on the development of imaging devices for charged particle radiation using TL or OSL phosphors (Research collaborator: QST-NIRS(National Institute of Radiological Sciences))
2. Studies on the development of neutron imaging devices using TL or OSL phosphors for Boron Neutron Capture Therapy (Research collaborators: Kyoto Univ., Kindai Univ. and Kanazawa Institute of Technology)







TL and OSL: When heat or light is applied to crystals irradiated with X-rays and so on (1), they can produce luminescence (2). This emission is called "TL" or "OSL", and it is correlated with the radiation dose. Taking advantage of this property, TL and OSL has been used for personal radiation dosimeters and so on.

Two-dimensional analyses: When crystals exhibiting TL or OSL are distributed in two dimensions, they can be used as a radiation imaging device. Photo (3) is an X-ray image of a USB stick and a one-yen coin taken with a TL dosimeter developed by our research laboratory, and (4) shows the measuring instrument. (eight patents applied for) Images with a very high resolution can be obtained. The instrument can be used as an imaging device for verification of high-precision radiation therapy plans, boron-neutron capture therapy, and the measurement of environmental radiation. This is anticipated to be a new dosimeter that can obtain different information from that provided by existing dosimeters, and it has also been featured in newspapers and journals.

Development of radiation detectors required in the medical field: In studies utilizing the heavy particle radiotherapy equipment for cancer at QST-NIRS (5), the nuclear reactors at Kindai Univ. (6) and Kyoto Univ., work is underway to develop methods to measure radiation quality and dose distribution using TL or OSL. In order to achieve this, it will be important to precisely measure TL or OSL and unravel its mechanism. Based on scientific evidence, we are developing state-of-the-art radiation detectors required in the medical field. One example is a human phantom dosimeter used to validate radiation therapy plans.(7)

Medical Radiation Measurement

Faculty in charge: Shinnosuke Matsumoto
Email : matsumoto.shinnosuke@tmu.ac.jp,　Room: 515

◯Outline of Laboratory

We evaluate radiation doses and health effects in radiotherapy and radio-diagnosis with various approach such as measurement and numerical simulation. We conduct research from viewpoint of medical physics and radiation protection.

※keywords

Heavy-ion therapy, Photon therapy, Computed Tomography, Dosimetry, Radiation protection, Cancer risk assessment, Development of radiation detector, Monte-Calro

◯Main research topics

- Organ dose evaluation during radiotherapy using an ultra-compact spherical dosimeter (Partnership : National Institutes for Quantum Science and Technology)
- Dose evaluation of secondary radiation generated during particle therapy based on measurements and calculations (Partnership : National Institutes for Quantum Science and Technology)
- Development of diamond detector for measurement of y-distribution in particle beam (Partnership : National Institutes for Quantum Science and Technology, Gunma University)
- Prediction of secondary cancer risk after radiotherapy using Monte Carlo calculations (Partnership : National Institutes for Quantum Science and Technology, Japan Atomic Energy Agency)

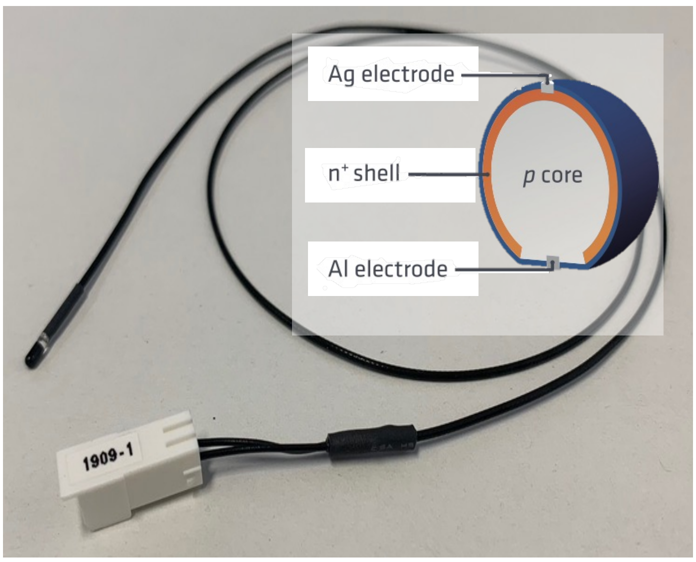


Fig. 1 ultra-compact spherical dosimeter

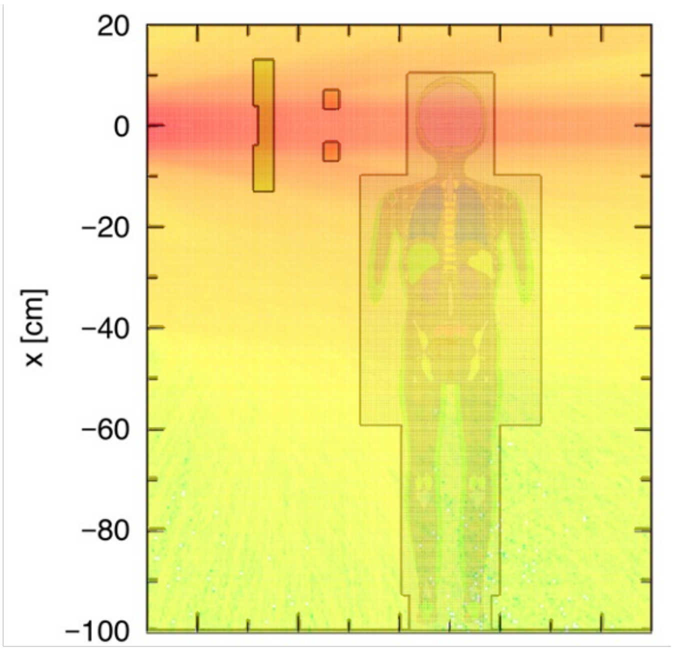


Fig. 2 Secondary dose assessment during particle therapy using Monte Carlo calculations

Diagnostic Medical Imaging

Akira Furukawa, MD, PhD, Takako Shirakawa, MD, PhD

In our research laboratory, we; diagnostic and interventional radiologist radiologists mainly conduct clinical studies on abdominal diagnostic imaging focusing on CT scans, MRI and ultrasound, and interventional radiology. Firstly, targeting the early detection of emergent diseases by advancement of diagnostic imaging that can lead to appropriate treatment options, we collect and analyze images of patients with various diseases causing acute abdominal conditions. We also disclose typical and characteristic imaging findings of these diseases, as well as, the diagnostic performance of various imaging tests for better understanding of values and limitations of each method. Secondary, we will develop morphofunctional imaging on gastrointestinal contractions, as well as related evaluation methods. Thirdly, diagnostic utility of ultrasonography using state-of-the-art machine for subcutaneous, joint, thyroid and breast diseases are investigated for further progress in diagnosis.

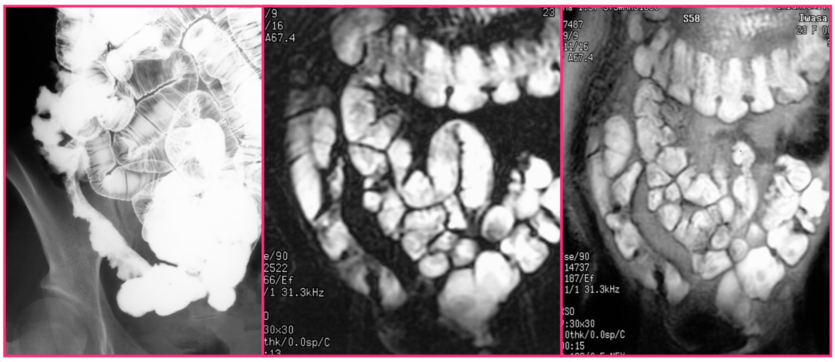
【Main Topics】

- # Performance and indication of MDCT for GI bleeding and bowel ischemia
- # Imaging Diagnosis for acute abdomen and various intestinal disorders
- # Analysis of bowel contraction using MRI
- # Morphological analysis of the liver in liver cirrhosis
- # Ultrasound assessment of disorders of the superficial organs

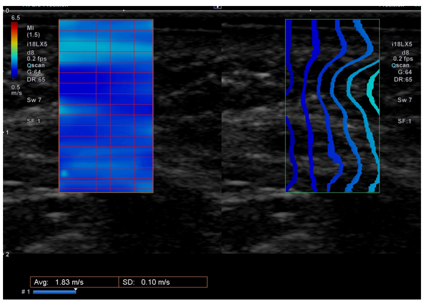
【Diverticular hemorrhage】

Angiogram　　Contrast –enhanced CT

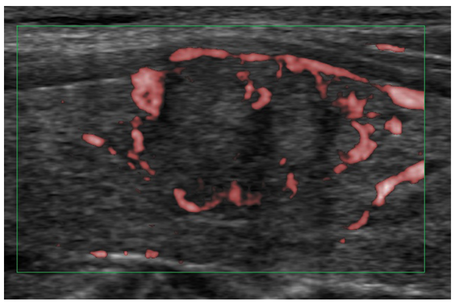
【Crohn Disease】



Barium study　　MR (SSFSE with fat saturation)　　MR (SSFSE)



【Ultrasound elastography of buccinator】



【Power-Doppler ultrasonography of thyroid gland】

Diagnostic Imaging Systems Engineering

Faculty in charge: Atsushi Senoo

1. **Research:** My research projects are useful for medical technicians working in clinical settings, as well as patients or people suffering from diseases or disabilities and their family members.

1. Analysis of brain functions using MRI (functional MRI and diffusion tensor analysis)

We clarify the process of recovery from brain diseases and develop new diagnostic methods by using an MRI system to identify activated sites in the brain and detecting anomalies of the cranial nerve fibers. In addition, we also work on new image processing techniques for analyses and programming of MR imaging procedures (fMRI and diffusion).

2. Development of new MRI imaging procedures

In this research laboratory, we are developing various new imaging sequences and image reconstruction methods for clinical MR devices. We use PHILIPS GOLC for programing imaging sequences, and the C language, ITT Corporation's IDL and Mathwoks Corporation's MATLAB to develop image reconstruction methods.

3. Computer assisted diagnosis (CAD) with time-varying image processing

We are studying medical applications of a time-varying image processing method that can track objects in an image, and developing computer diagnostics such as gastroenterological diagnosis with X-ray fluoroscopic images of the stomach, three-dimensional analysis of myocardial dynamics based on gated myocardial SPECT images, and so on.

4. Risk management and patient care

What are the most common mistakes health care staff make in medical practice? We also conduct a survey on how they deal with patients and so on.

Functional MRI	Diffusion tensor analysis
Is it true that language is processed only in the left brain? Although it has been said for about the last 100 years that the repetition of words ─ (1) understanding words by listening (sensory language), and (2) repetition of words aloud (motor speech) ─ involves the left brain, it had not been possible to visualize this. Last year, we succeeded in visualizing these conditions for the first time in the world, and made it clear that the right brain as well as the left brain is also involved in speaking words. This research can clarify the process of recovery from speech disorders, and will help evaluate the effectiveness of speech therapy.	Can mental disorders be diagnosed with diagnostic imaging? Obsessive-compulsive disorder and schizophrenia are said to involve an abnormal arrangement of synapses, compared with the normal structure. Therefore, we developed a system to detect abnormal neural arrangements.

Development of new MRI imaging procedures	CAD with time-varying image processing
Development of MR imaging procedures with no noise Although MR devices have the advantage of obtaining cross-sectional images without using radiation, they produce a lot of noise during imaging. If this research can be put to practical use, it will be possible to greatly change the environment of laboratories. For example, examinations could be performed with music in the background in an MR room. In addition, an analysis of stimuli such as voices or sounds would be possible in imaging brain functions, which could make a significant contribution to the advancement of cerebrophysiology.	Computer recreation of gastroenterological diagnosis procedures by experienced doctors X-ray fluoroscopy is performed by doctors, and the accuracy of diagnosis is considered to vary greatly depending on the proficiency of the doctor making a diagnosis. In this research, we develop a diagnosis support system aiming to make computer recreations of diagnoses by experienced doctors. So far, we have made it possible to identify sites of stenosis with time-varying image processing.

2. **Education**

By following a curriculum of language acquisition specially created by the research laboratory, students can learn more about medical image processing and MR imaging sequences, and everyone will be able to perform programming. We are putting our efforts into developing human resources who can play active roles as core staff members at hospitals, research institutes, and businesses.

Diagnostic Imaging systems Engineering

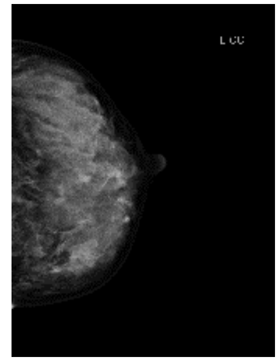
Toru Negishi

Research

We perform the measurement of each medical imaging equipment, and we examine optimization of the medical radiation exposure.

✓ Mammography

PMMA(mm)		
Breast Thickness(mm)	1	40
Air Karma(mGy)	7.667	
Breast Thickness(mm)	40	
HVL(mmAl)	0.338	
Spectrum	Mo/Mo	
Breast Glandularity(%)	50	
Average Glandular Dose(mGy)	1.747	



Currently, the examination method recommended for breast cancer screening is mammography, the breast density of the image affects cancer detection. Especially high concentration breast is considered as one of findings with high risk of carcinogenesis. Therefore, we analyze the characteristics of the device from both aspects of image quality and exposure, and consider optimization of mammography.

✓ Optimization of the medical radiation exposure (Diagnostic Reference Levels)

A diagnostic reference level of medical exposure in our country was formulated in 2015. Therefore, we examine the optimization of image quality and exposure dose.

✓ Quality Control of X-ray equipment

Based on the IEC standards, we examine the accuracy control of the diagnostic X-ray equipment's.

Education

We will lectures on X-rays diagnostic Imaging equipment, and we educate latest IEC or paper. We practice it about a measurement technology of the X-ray diagnostic equipment.

Medical Imaging and Informatics

Faculty in charge: Norio Sekine

We are working on medical image analyses and educational technology.

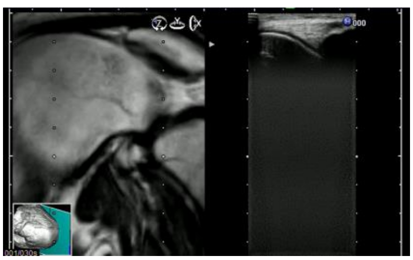
1. Evaluation of the quality of ultrasound images

○ Development of an automated screening system for breast cancer.

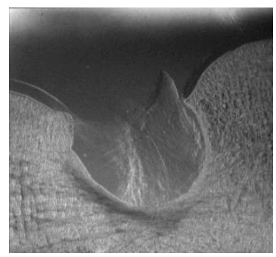
○ Development of a screening system for potential patients with osteoarthritis of the knee.

2. Radiation imaging for medical applications

○ Development of a reconstruction algorithm for tomosynthesis images with a refraction contrast technique.



Simultaneous display of MRI and ultrasound images



Depiction of ligaments and cartilage in a monochromatic X-ray

3. Development of an education support system for radiological technology

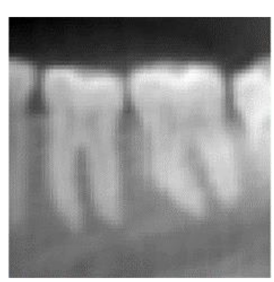
○ Research on positioning support for augmented reality (AR) technology and its applications.

○ Simulations of X-ray images for education using CT data.

Virtual goniometer with real imaging and augmented reality

Imaging simulation consistent with information about posture

3D-CG display examples



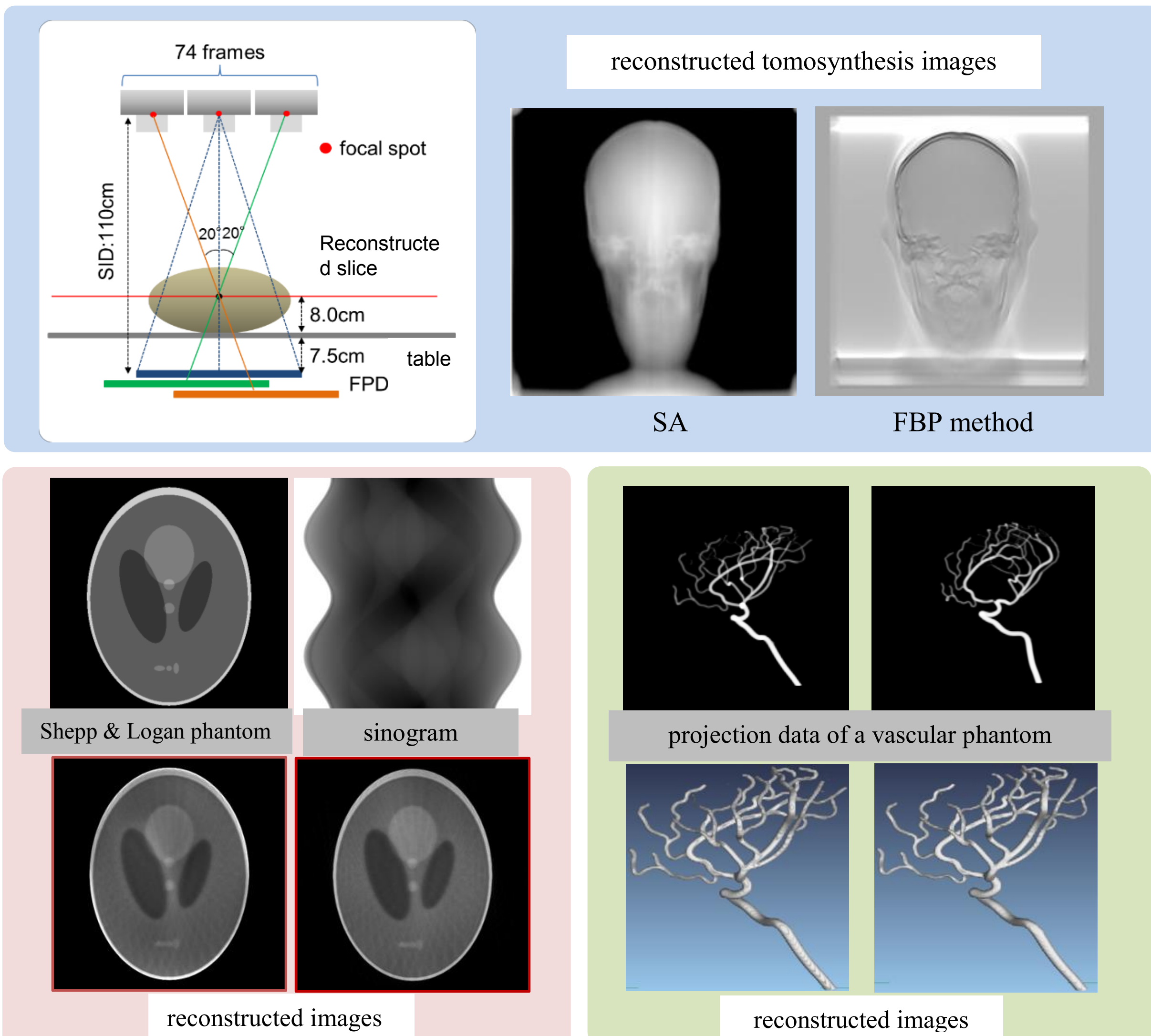
Dental X-ray simulation

Medical Imaging and Informatics

Faculty in charge: Yoshiyuki Nyui

1. [Research]

We are conducting fundamental research on medical image concerned with image reconstruction techniques. We mainly study image reconstruction of tomosynthesis. And we also study to reconstruct images from a few projection data using iterative reconstruction techniques (algebraic reconstruction technique, a maximum likelihood expectation maximization method and so on).



2. [Education]

In advanced courses on Medical Imaging and Informatics, we give lectures on the basic principles of image reconstruction methods. Furthermore, in the practical exercises of advanced courses on Medical Imaging and Informatics, students will actually create a simple image reconstruction program such as simple back-projection, filtered back-projection and iterative image reconstruction method. And further learn more about image reconstruction method by changing various parameters (such as projection angles, number of projections and so on).

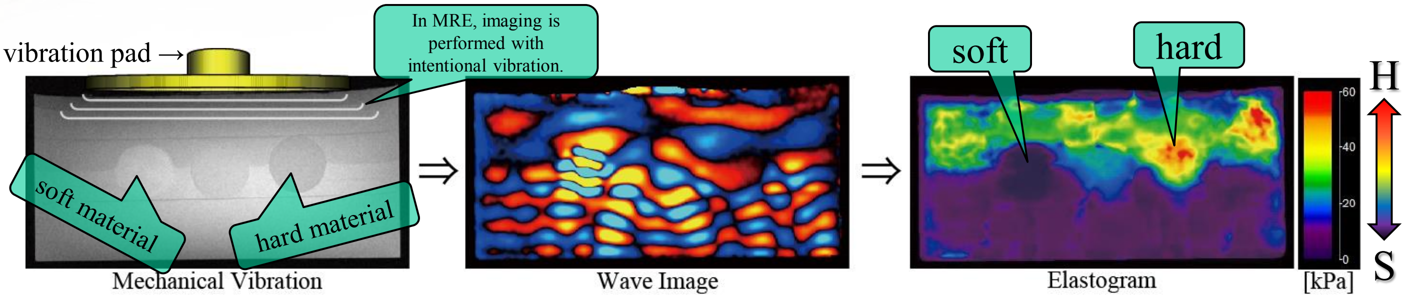
Details of research conducted in the Numano research laboratory

Research project in Numano research laboratory: MRI

We make use of MRI to carry out research on techniques to visualize *in vivo* information that has been difficult to imaging.

A technology to create an image of "hardness" *in vivo*: Elastography

We are advancing MR Elastography (MRE) that does not rely on the technology of MRI manufacturers, and have demonstrated MRE with our unique technology. MRE can create an image of "hardness" *in vivo* that had been impossible to image with traditional MRI technology. Thus, we can now obtain imaging data reflecting a distribution of hardness, which was not possible to image in the past.

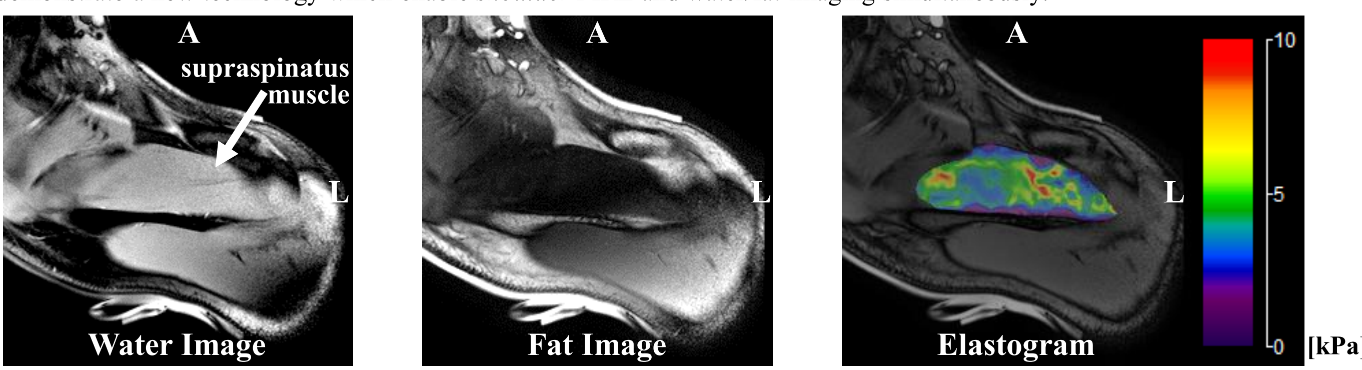


A Simple Method for MR Elastography: A Gradient-Echo Type Multi-Echo Sequence. *Magn. Reson. Imaging* 2015 33:31-7

Development of a new MRE technology

Ethics Committee for Safety and Ethics in Research, Faculty of Health Sciences, Tokyo Metropolitan University (Acceptance Nos. 10085, 13001)
Japanese Patent No. 6548257

We demonstrate a new technology which enable *shoulder* MRE and water/fat imaging simultaneously.



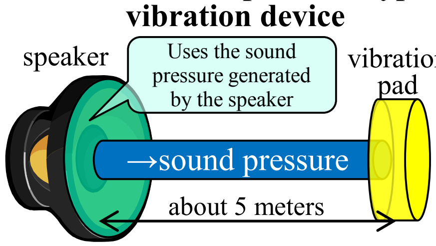
Fat is often a source of problems in MR imaging. It tends to have high signal intensity at all contrasts, which could mask image changes reflecting various tissue pathologies. We have developed a new method for simultaneous acquisition of MRE and two-point Dixon imaging (water/fat imaging) on a conventional MR imager.

Simultaneous Acquisition of MR Elastography and Two-point Dixon Imaging. *ECR 2018: ESR/EFRS Radiographer Awards*

Development of a new vibration device for MRI

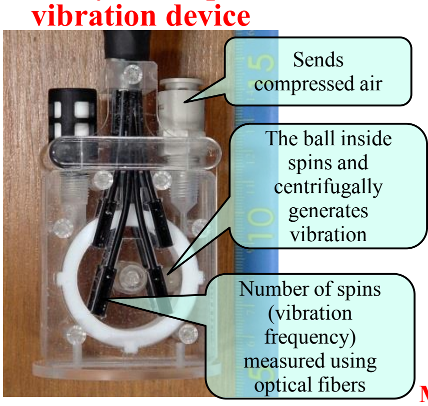
Japanese Patent No. 5376593

Current sound pressure-type vibration device



- Limited to a low vibration frequency range (the image resolution of MRE is low).
- The tube connecting the speaker to the vibration pad measures up to several meters (causing a great loss of vibrational energy)

Newly developed vibration device



There are a number of advantages compared with a sound pressure-type vibration device.

- High vibration frequency range (the image resolution of MRE is higher).
- Directly vibrate the target (resulting in little loss of vibrational energy).
- Even a small device can generate strong vibration.
- As is the case with the sound pressure type, this new device does not influence MRI since it is made of non-magnetic materials.

In this research laboratory, we are also developing devices that will play a part in next-generation MRE technologies, together with MRE techniques with a relatively high feasibility.

Magnetic Resonance Elastography using an air ball-actuator. *Magn. Reson. Imaging* 2013 31:939-46

We look forward to your questions and inquiries. TEL: 03-3819-7353, E-mail: t-numano@tmu.ac.jp, Numano research laboratory

TOKYO METROPOLITAN UNIVERSITY

Medical Image Science based on Biology

Supervisor： Junichi Hata, Ph.D.

Research Concept

With medical imaging science at the core, we aim to elucidate the contrast mechanisms of medical images and understand the relationship with life science phenomena by actively incorporating cross-disciplinary research. We will also aim to develop various imaging, measurement, and analysis technologies to "understand using visualization" the complex dynamics of biological systems.

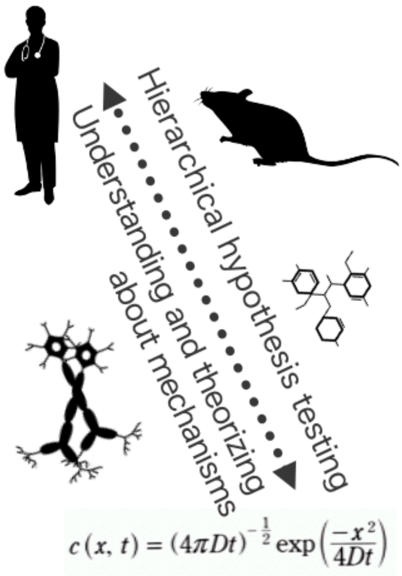
Main research topics

- Visualization of aquaporins and elucidation of the role of aquaporins in biological functions.
- Development of ultra-early diagnosis method of Parkinson's disease/Alzheimer's disease.
- Development of brain region identification technology using water diffusion measurement technology
- Understanding the specificity of brain activity by anesthesia mechanism
- Development of single cell imaging technology using genetic reporter and its application
- Development of imaging method for evaluation of spinal cord injury process by iPS cell transplantation
- Development of an innovative imaging to skeletal muscle cell types and applicability to sports medicine

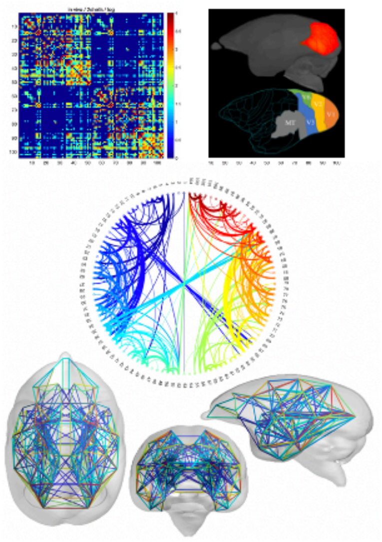
Main Collaborating Institutions

Tokyo University, Osaka University, Nagoya University, Kyoto University, Keio University, The Jikei University School of Medicine, National Center of Neurology and Psychiatry, RIKEN, National Institute of Radiological Sciences, Central Institute for Experimental Animals, Primate Research Institute, John Hopkins University (USA), Cold Spring Harbor Laboratory (USA) University of Pittsburgh (USA), etc.…

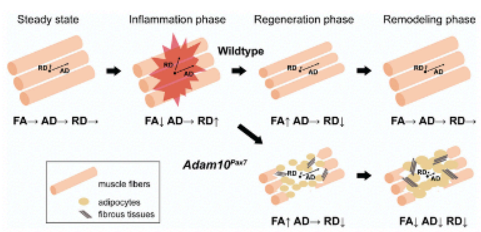
Research Concept



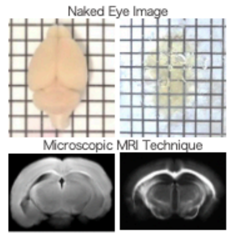
Brain Structure and Function Network Research



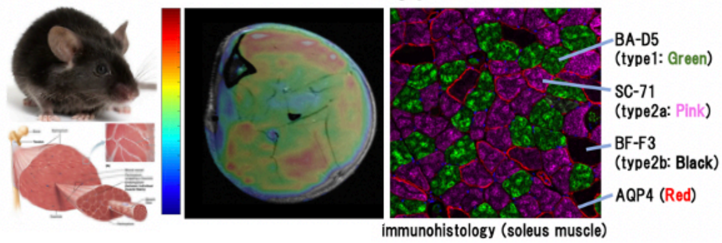
Visualization of cell regeneration process



Transparent Brain Technology



Non-invasive technique for discrimination of skeletal muscle Type I and II cells



We aim to educate engineers and researchers who have a broad perspective beyond their field of specialization and who can demonstrate a high degree of cooperation and leadership. We actively engage in exchanges with researchers outside of our field of expertise, and while pursuing the fundamentals of theory, we develop our research with an understanding of how to enjoy medical research. Feel free to contact us with any questions or concerns about our laboratory.

Room: 514 & 408, Email: j-hata@tmu.ac.jp