Nuclear Medicine Physics and Health Physics

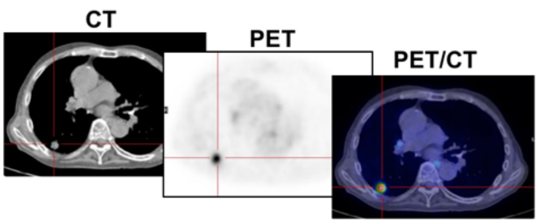
Supervisors: Professor Kazumasa INOUE, Associate Professor Masaru TAKABATAKE

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.

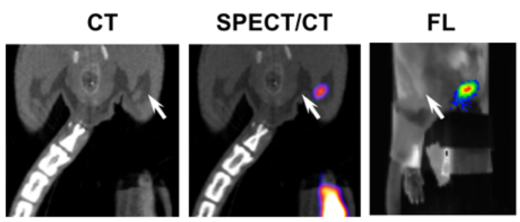
We have had about 100 publications appear in academic journals including the *Journal of Nuclear Medicine*, *Radiation research, Marine Pollution Bulletin, Scientific Reports* and *PLOS ONE*, and we have received over 30 honors from professional societies for our contributions to nuclear medicine and health physics. More detailed information about supervisors can be found at "https://researchmap.jp/kzminoue" and "https://researchmap.jp/012108240413mt". Our supervised students have received 28 doctoral degrees and 70 master's degrees, and all of them are active in the field of clinical research and education as of FY 2024. 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).

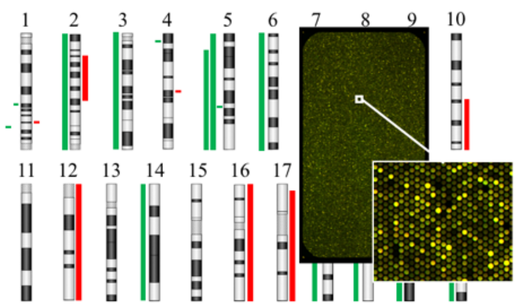
Respiratory-gated PET/CT imaging



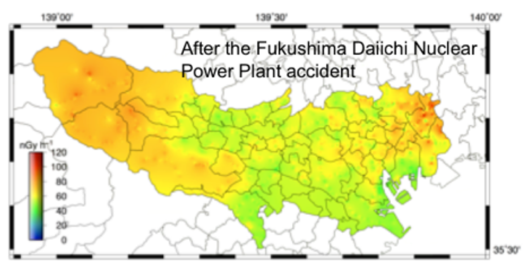
Multimodal imaging



Genome analysis



Absorbed dose rate in air in Tokyo

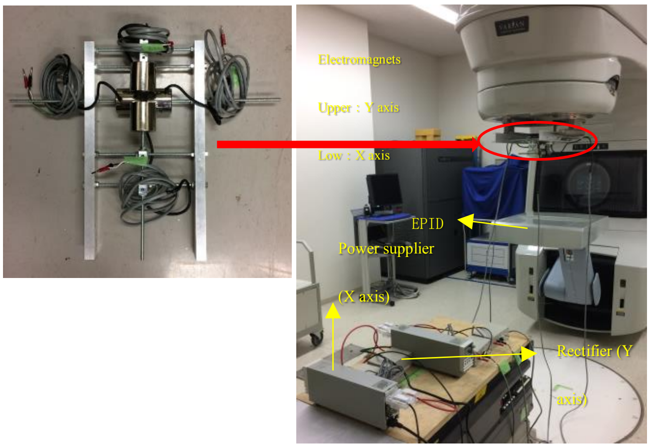


Radiation Oncology Physics

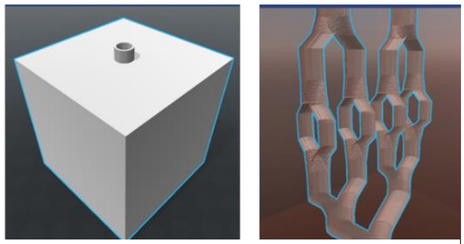
Faculty in charge: Atsushi Myojoyama

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



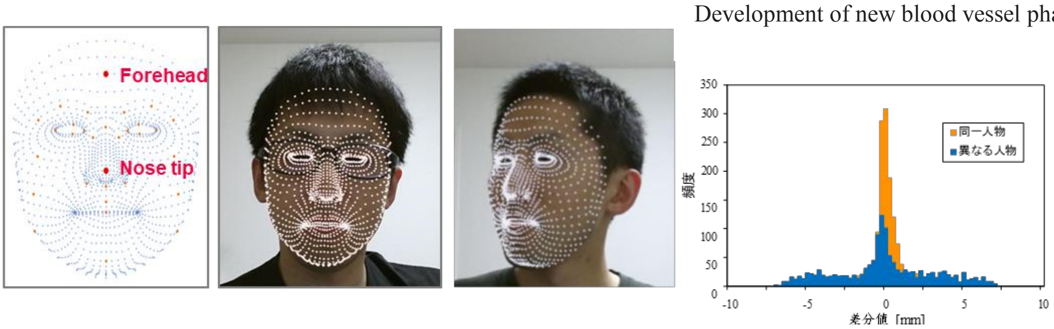
Development of image acquisition device by bending of electron beam using electromagnets



3D phantom model

blood vessel model

Development of new blood vessel phantom



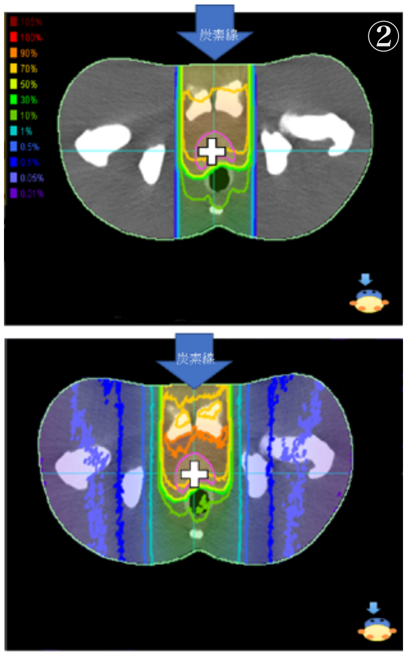
Automated patient authentication by face authentication using Kinect

TOKYO METROPOLITAN UNIVERSITY
東京都立大学

Radiation Oncology Physics

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

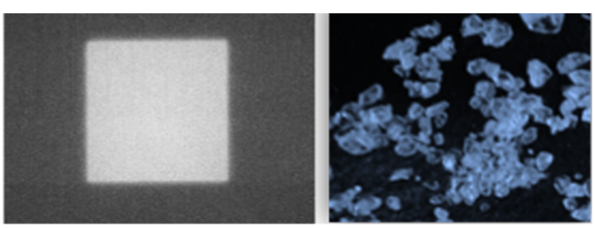
Faculty in charge: Kiyomitsu Shinsho

Research laboratory policies：We place great importance on developing the ability to solve problems independently. Try tackling questions that no one yet has the answer to. In our laboratory, you can gain experience in the synthesis of radiation-sensitive phosphors, chemical analysis, optical measurement, data analysis, and the development of measurement systems.

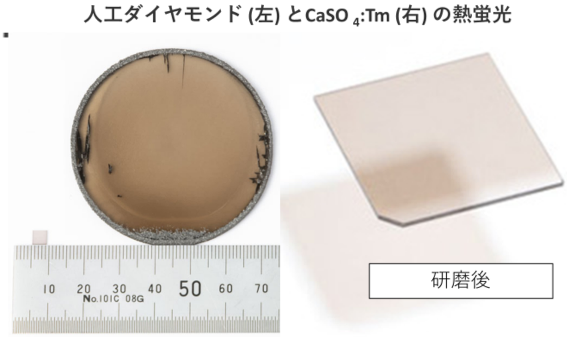
Research details：We are developing next-generation radiation detectors tailored to contemporary needs by utilizing the luminescence properties—such as thermoluminescence and optically stimulated luminescence of naturally occurring minerals and lab-grown diamonds that have long been known. Advancements in radiation-based medical technologies have significantly improved diagnostic capabilities and dramatically enhanced the effectiveness of cancer treatment. However, these advancements demand corresponding development in radiation detection technologies, which remain highly challenging due to the complex interplay of various physical interactions. Through collaborative research with other universities and companies, and by leveraging cutting-edge research facilities such as accelerators and nuclear reactors, we aim to solve pressing issues in radiation measurement technology within clinical settings.

Current major research projects

1. **Study on the Development of Imaging Devices for Proton and Heavy Ion Beams**
   (Research collaborator：University of Tsukuba, NIRS-QST)
2. **Study on the Development of Detectors Compatible with Ultra-High Dose Rate (FLASH) Electron Beam Irradiation** (Research collaborator：Kyoto University)
3. **Study on Discriminative Measurement of Neutrons and Gamma Rays in Boron Neutron Capture Therapy (BNCT)** (Research collaborator：Kindai University, Kyoto University, KIT)
4. **Study on the Development of Diamond-Based Radiation Detectors for Medical Applications** (Research collaborator：Orbray Co., Ltd., Tohoku University, Osaka University, Tohoku Institute of Technology, KIT)
5. **Research on Medical Radiation Exposure and the Development of Radiation Detectors for Eye Lens Dose and Mean Glandular Dose Measurement** (Research collaborator： NIRS-QST)

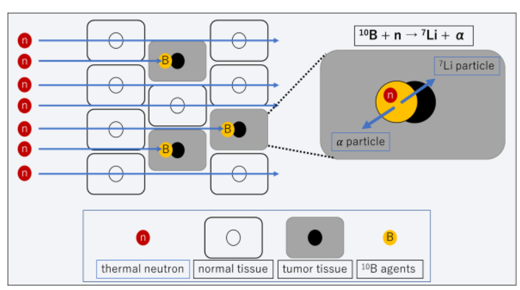


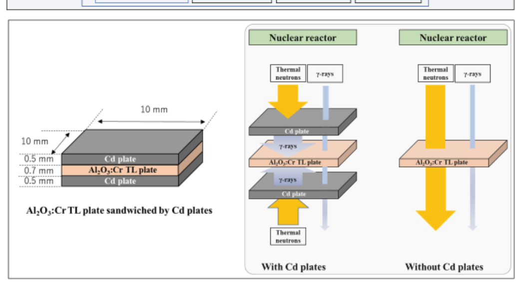
人工ダイヤモンド (左) とCaSO$_4$:Tm (右) の熱蛍光



The World's Largest Lab-Grown Diamond by Orbray (https://orbray.com/)

Development of a Radiation Detector Using Diamond
Inventors: Kiyomitsu Shinsho, Seong woo Kim, Koji Koyama, Go Okada
Patent Application Number: 2023-208775
Title of the Invention: Dosimeter Material, Measuring Device, and Measuring Method
Applicants: Tokyo Metropolitan University Corporation, Orbray Co., Ltd., Kanazawa Institute of Technology





Overview of Boron Neutron Capture Therapy (Top) and Principle of Selective Gamma-ray Measurement in Mixed Neutron and Gamma-ray Fields (Bottom)

Kiyomitsu Shinsho, et.al.
Japanese Journal of Applied Physics 62, 010502 (2023)

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)

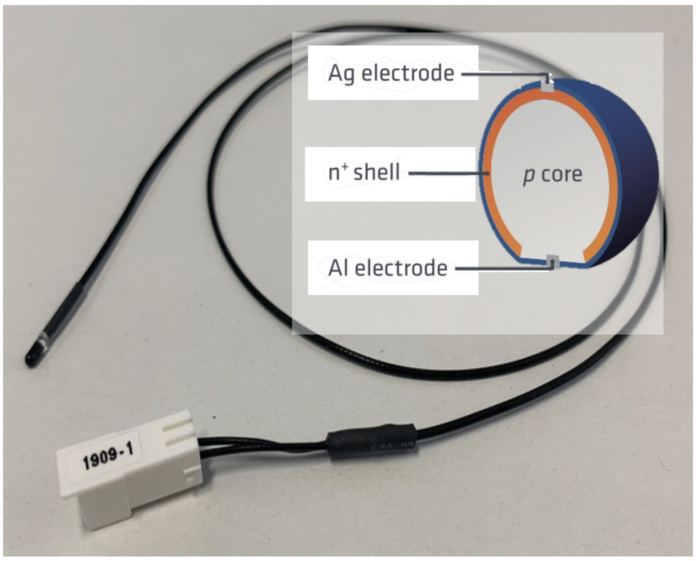


Fig. 1 ultra-compact spherical dosimeter

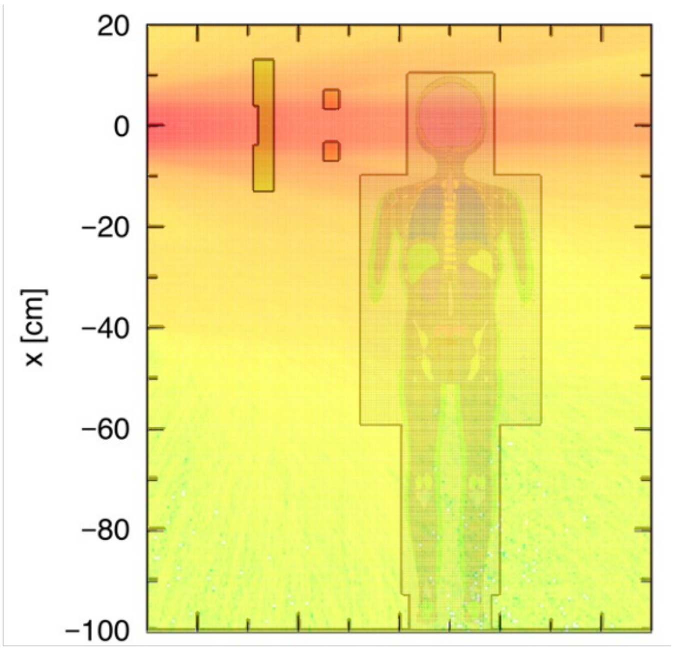


Fig. 2 Secondary dose assessment during particle therapy using Monte Carlo calculations

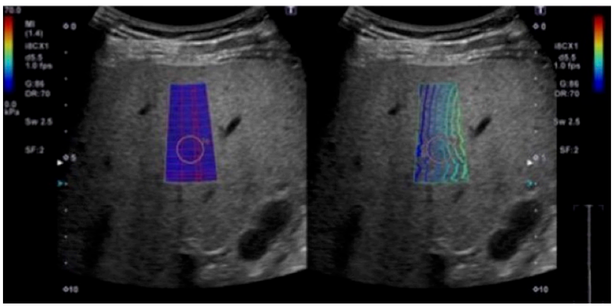
Diagnostic Imaging

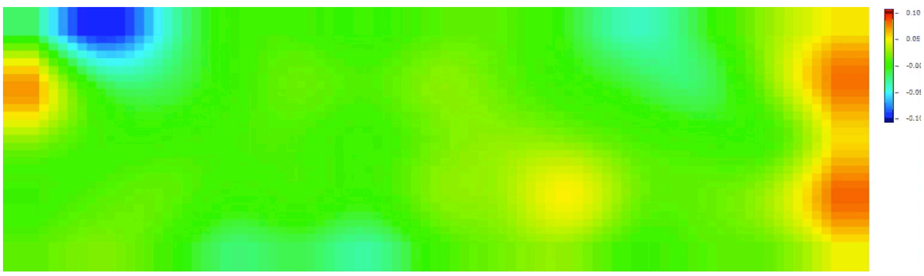
Takako Shirakawa, M.D., Ph.D., Haruyasu Yamada, M.D., Ph.D.

We primarily conduct imaging diagnostics and research centered around CT (computed tomography), MRI (magnetic resonance imaging), US (ultrasound), and NIRS (near infrared spectroscopy). We collect images of various diseases, analyze them, clarify the characteristics and limitations of different examination methods, and develop more accurate diagnostic methods and their evaluations.

Main Research Topics

Ultrasound Diagnosis of Superficial Organs and Liver
Enhancement of Thrombolysis Using Microbubbles (Ultrasound Contrast Agents) and Clinical General-Purpose Ultrasound Devices (Collaborative research with Tokyo Jikei University School of Medicine (Jikei University) and International University of Health and Welfare (IUHW)
Enhancement of Thrombolysis in Vascular Access Thrombosis for Hemodialysis Using Ultrasound Contrast Agents (Collaborative research with Jikei University and IUHW)
Cerebral Blood Flow During High-Level Brain Activity with High-Concentration Oxygen Inhalation using NIRS (Collaborative research with Jikei University and Kyoto Prefectural University of Medicine)
Statistical Analysis of Brain MRI





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

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.

Diffusion tensor analysis

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

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.

CAD with time-varying image processing

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

Supervisors: Toru Negishi

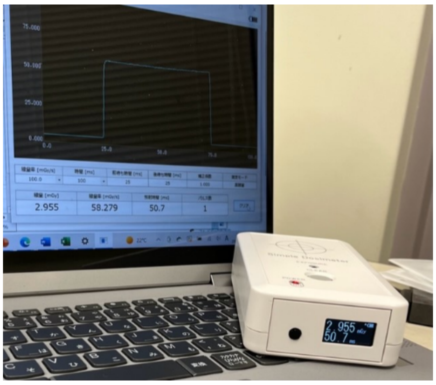
Measurement and analysis of diagnostic imaging equipment are performed to optimize the image quality and medical exposure of diagnostic imaging systems.

Breast Cancer Research

Currently, mammography is the evidence-based screening method used for breast cancer screening, and the quality of the image has an impact on cancer detection. In mammography, the quality of the image is a major factor in the detection of cancer. In breast cancer imaging, high-density breasts, which are considered to be particularly common among Japanese women, are considered to be one of the findings that carry a high risk of carcinogenesis. In addition, the mammary tissue is a radiosensitive tissue, so it is important to control the average glandure dose. Therefore, we will study the optimization of image quality and medical radiation exposure by performing characterization using the latest tomosynthesis mammography system from the two aspects of image quality and radiation exposure.

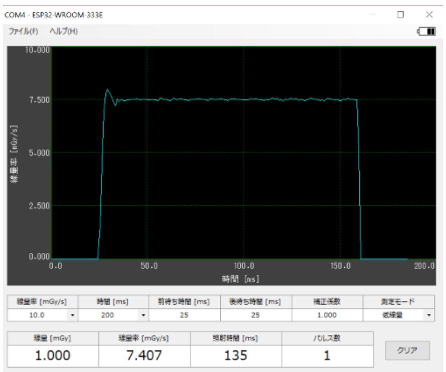
Optimization of Medical Exposure

The Japan DRLs (Diagnostic Reference Levels) for medical exposure in Japan were established in 2015. The optimization of image quality and exposure dose in the medical field will be discussed through the optimization of measurement methods, such as the development of semiconductor dosimeters.



Accuracy Control of Diagnostic X-ray Equipment

In recent IEC standards, acceptance tests, constancy tests, and quality assurance of diagnostic X-ray equipment have been discussed and published as the IEC standards for routine testing methods of X-ray equipment, and are being converted to JIS as needed. Based on these standards, we will incorporate new methods for accuracy control of diagnostic X-ray equipment and suggest them to the international standards.



Medical Imaging and Informatics

Faculty in charge: Norio Sekine

We are working on medical image analyses and educational technology.

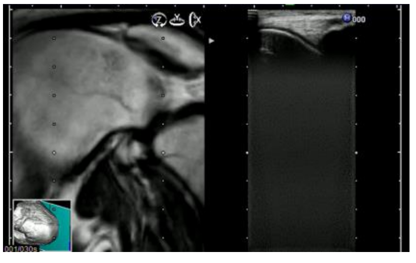
1. Evaluation of the quality of ultrasound images

○ Development of an automated screening system for breast cancer.

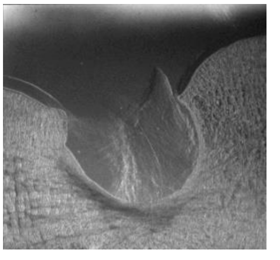
○ Development of a screening system for potential patients with osteoarthritis of the knee.

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

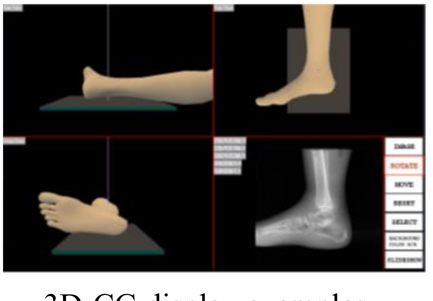
3. Development of an education support system for radiological technology

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

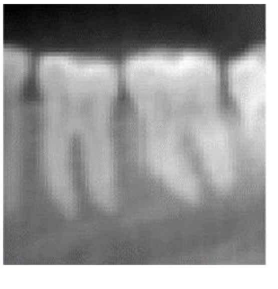
○ Simulations of X-ray images for education using CT data.

Virtual goniometer with real imaging and augmented reality

Imaging simulation consistent with information about posture



3D-CG display examples



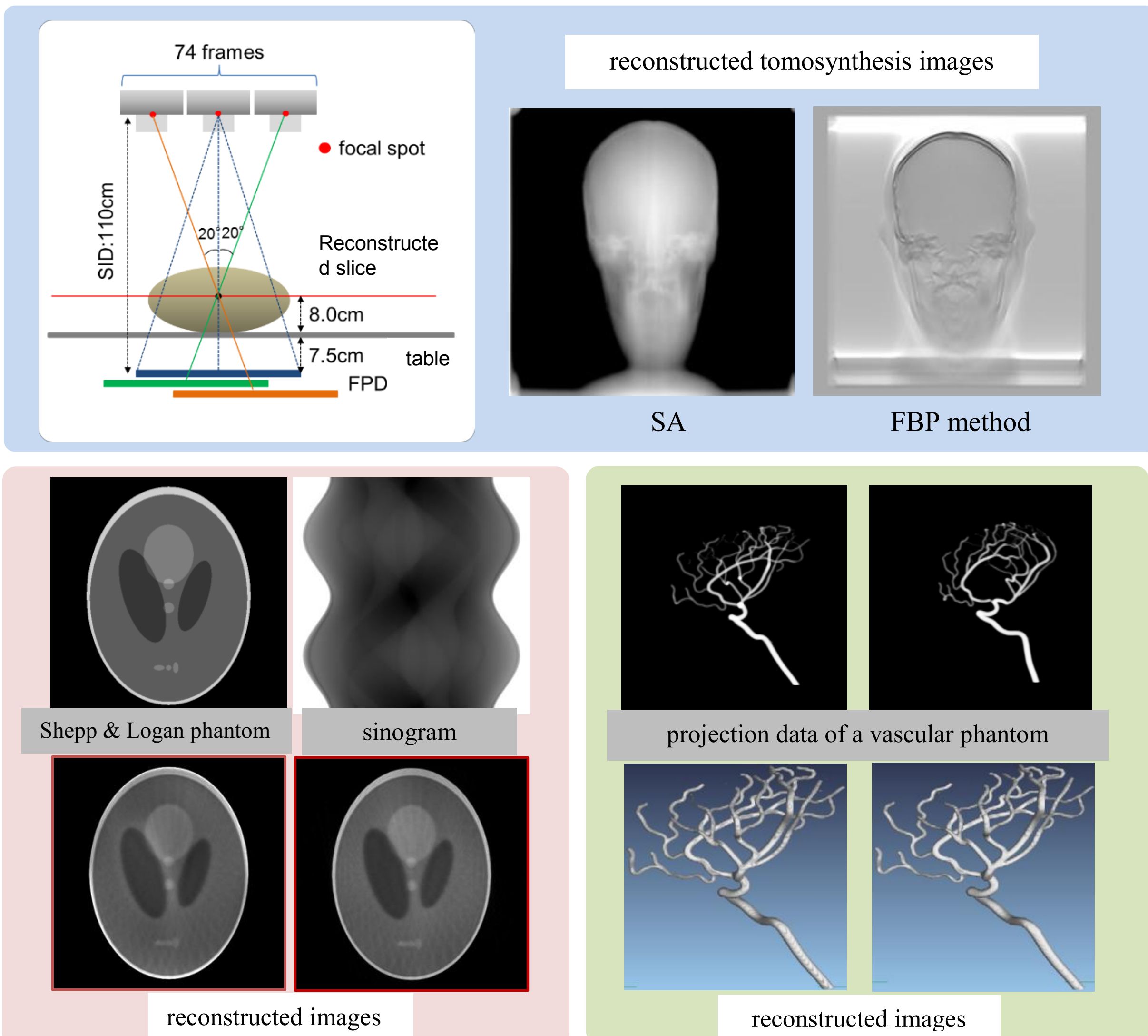
Dental X-ray simulation

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).

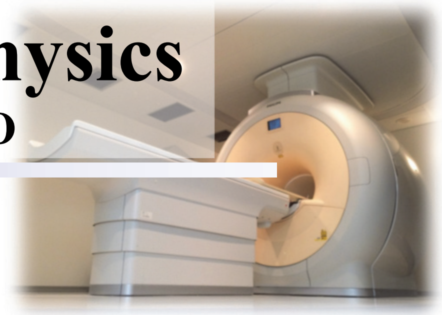


2. [Education]

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).

Diagnostic Radiology Physics

Supervisor: Tomokazu NUMANO

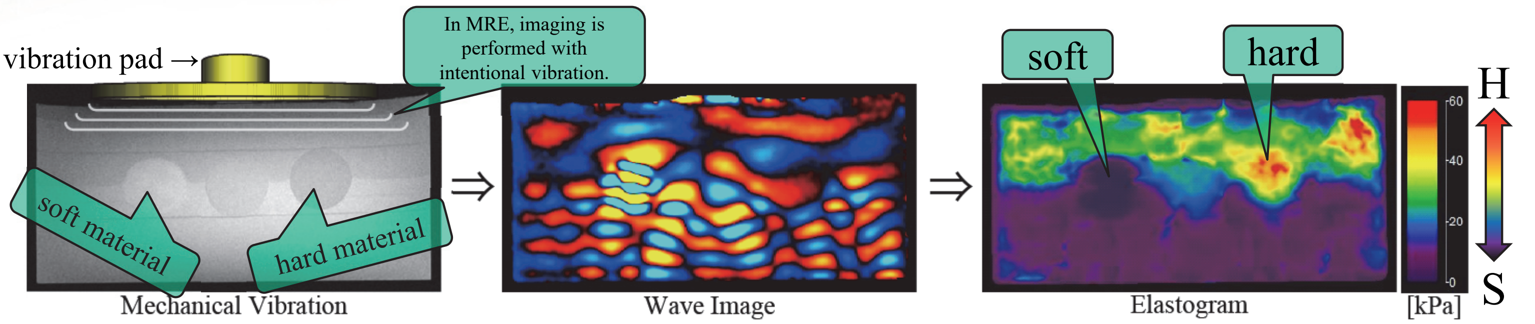


Research project in Numano research laboratory: MRI

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.

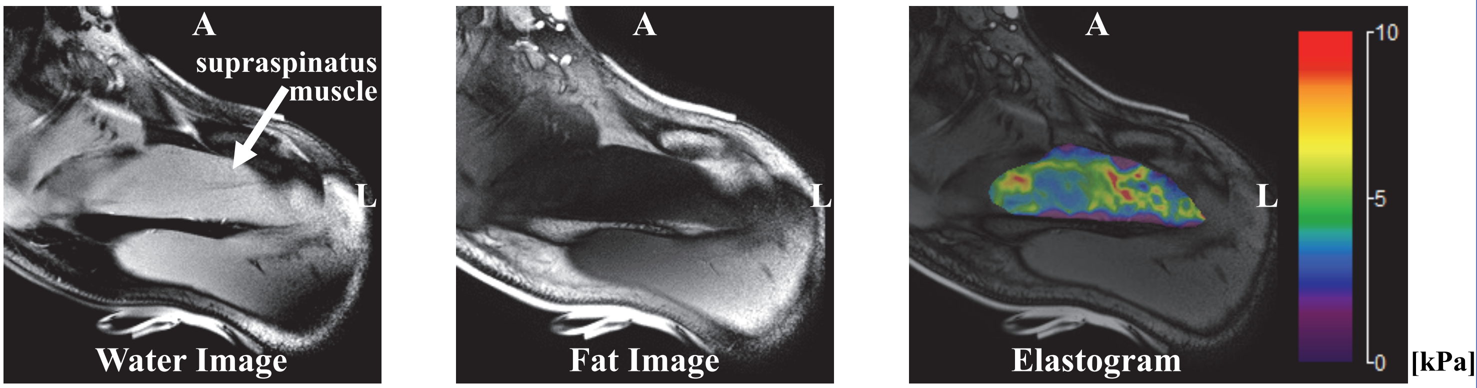


A Simple Method for MR Elastography: A Gradient-Echo Type Multi-Echo Sequence. *Magn. Reson. Imaging* 2015 33:31-7

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.



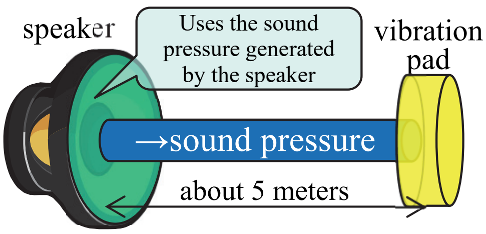
Fat is often a source of problems in MR imaging. It tends to have high signal intensity at all contrasts, which could mask image changes reflecting various tissue pathologies. We have developed a new method for simultaneous acquisition of MRE and two-point Dixon imaging (water/fat imaging) on a conventional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

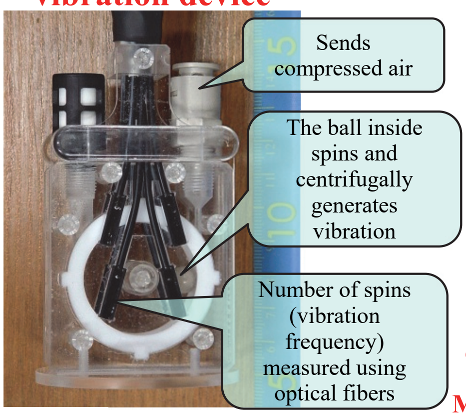
Japanese Patent No. 5376593

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

Diagnostic Radiology Physics

Supervisor： Junichi Hata, Ph.D.

Research Concept

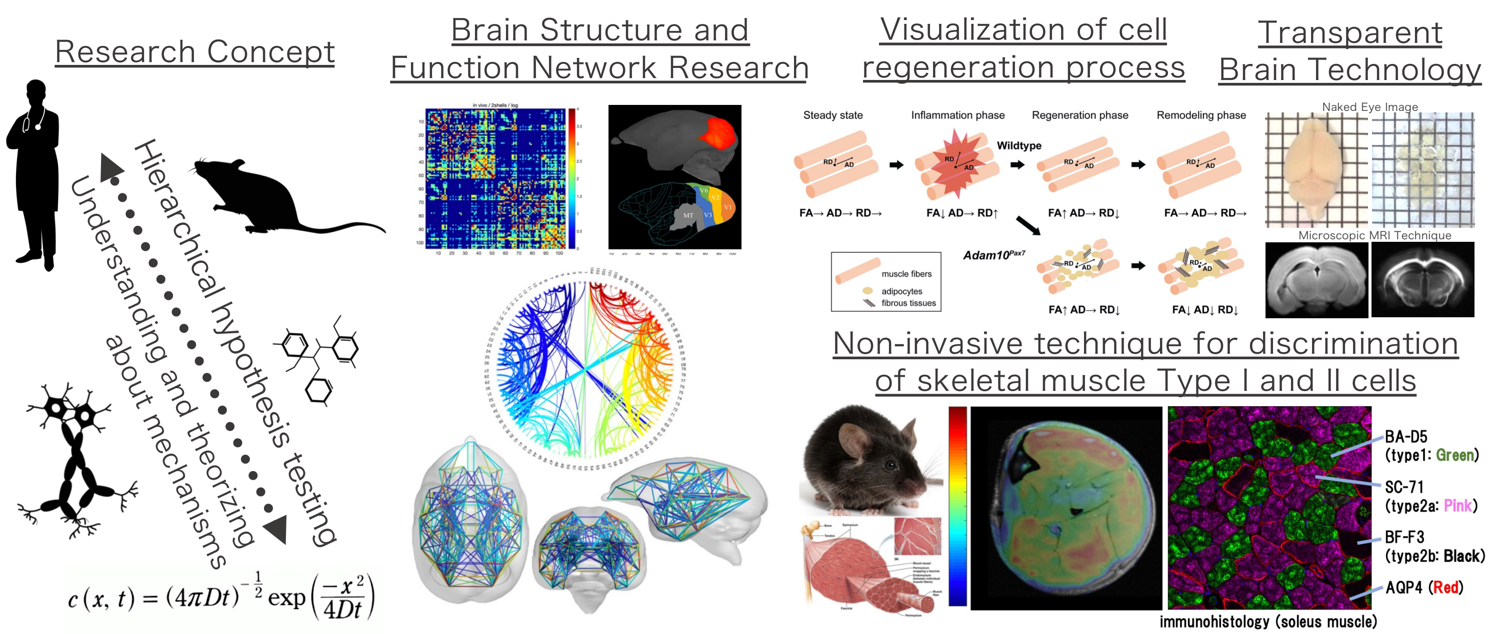
With medical imaging science at the core, we aim to elucidate the contrast mechanisms of medical images and understand the relationship with life science phenomena by actively incorporating cross-disciplinary research. We will also aim to develop various imaging, measurement, and analysis technologies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



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