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The Future of Medicine Using Big Data and AI

The use of 'Big Data' is growing across a wide range of fields, but in none are expectations so high as in medicine. AI-based analysis of huge volumes of medical data has the potential to transform healthcare in areas such as preemptive medicine and personalized medicine. Tokyo Medical and Dental University has reorganized its graduate school courses in line with the new 'future of medicine.' TMDU researchers are also making specific advances in these exciting fields.

Various researchers are applying the accumulating mass of medical Big Data from genomes, patient records and diagnostic samples to the development of next-generation medicine.

One area in the spotlight in terms of medical Big Data applications is preemptive medicine, which seeks to use genomic and other information to predict and prevent diseases through preemptive intervention. In Japan, where healthcare costs are rising rapidly, demand for such medical expertise in society is high.

With lifestyle diseases, which account for around 35% of medical costs, smoking, obesity and other environmental factors have a significant impact in addition to any congenital factors. Through integrated analysis of the complex web of medical information, researchers hope to discover unknown factors or mechanisms to help develop preventive interventions.

TMDU has reorganized its graduate program in preemptive medicine to enable an integrated approach for developing students active in the clinical and research spheres.

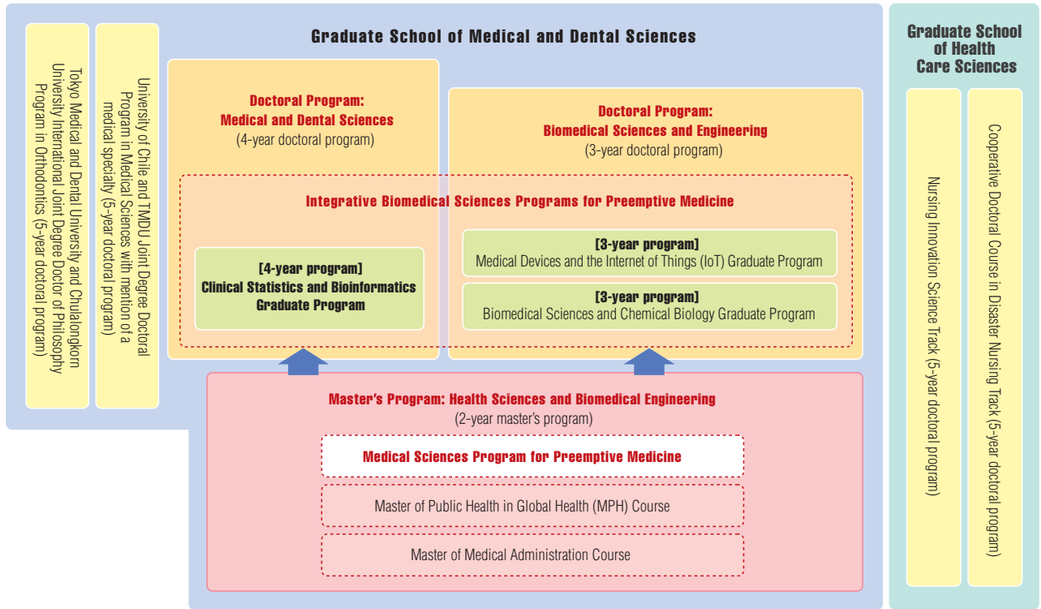
Development of Preemptive Medical Personnel via New Graduate Program

The reorganization is based on a goal of TMDU's Third Medium-term Plan that began in fiscal 2016, namely, to "create a global education and research center dedicated to integrative sciences for preemptive medicine." Effective from April 2018, the reorganization involves combining the Graduate School of Medical and Dental Sciences and the Biomedical Laboratory Sciences Track of the Graduate School of Health Care Sciences to establish the new Graduate School of Medical and Dental Sciences offering new programs for fostering people who can play leading roles in preemptive medicine.

Offering broader options for students wanting to specialize in preemptive medicine, the new programs include a master's program (Medical Sciences Program for Preemptive Medicine) and doctoral programs (Integrative Biomedical Sciences Programs for Preemptive Medicine). The doctoral programs are divided into a 4-year program for those studying Medical and Dental Sciences and a 3-year program for those studying Biomedical, Life and Health Sciences Engineering.

The programs adopt a broad approach to fields such as clinical statistics and biostatistics to help develop the ability to apply statistical and mathematical analysis to large volumes of medical data. The doctoral programs also include specialized programs in preemptive medicine such as the 4-year Clinical Statistics and Bioinformatics Graduate Program, in which students learn how to analyze databases integrating genomic information with patient records or to apply data mining techniques to lifestyle habits or environmental factors.


Professor
Hajime Karasuyama
Executive Director & Executive Vice President
University Innovation and Globalization



In the 3-year Medical Devices and Internet of Things (IoT) Graduate Program, students learn about bioinformatics and device engineering, two subjects now essential to the development of medicine and healthcare.

In the 3-year Biomedical Sciences and Chemical Biology Graduate Program, students develop problem-solving skills by applying AI and network solutions across a wide range of fields, with the core focus on disease elucidation and prevention based on drug development.

Combining Resources for an Integrated Academic Approach

Executive Vice President Professor Hajime Karasuyama, who led the reorganization of the graduate school, explains the move was about establishing an integrated approach across TMDU to teaching preemptive medicine as well as creating new academic structures.

"TMDU already had several departments involved in teaching, research and treatment related to preemptive medicine, including the Center for Personalized Medicine for Healthy Aging in the Medical Hospital. However, they did not really function cooperatively as an organic whole. By bringing these resources together, we have established new programs with a more integrated approach to preemptive medicine."

Parts of TMDU already operating in the area include the Center for Personalized Medicine for Healthy Aging, which undertakes prophylactic medical interventions based on environmental, genetic and other factors; and the Bioresource Research Center, which is building a database of genetic and clinical information. TMDU's Institute of Biomaterials and Bioengineering is also involved in the field with its development of sensing technology for collecting relevant medical data in the form of biomonitoring devices designed to monitor pulse, blood glucose and other vital signs as well as lifestyle habits in real time. The Medical Research Institute has also recruited specialists in medical science mathematics from RIKEN to establish the necessary personnel base for analyzing such data.

Prof. Karasuyama stresses that offering all the programs on preemptive medicine under the Graduate School of Medical and Dental Sciences is an important development for the future of preemptive medicine.

"Through this broad framework, our aim is to create a structure to allow those without a medical or dental sciences background–such as someone who has studied programming as part of an engineering degree, for example–to study preemptive medicine alongside medical and dental students. We think it is extremely valuable for people with varied academic backgrounds, such as clinical technologists and device development engineers, to study together."

TMDU is focused on promoting progressive research toward such a future.

Future of Medicine Using Genomic Big Data and AI

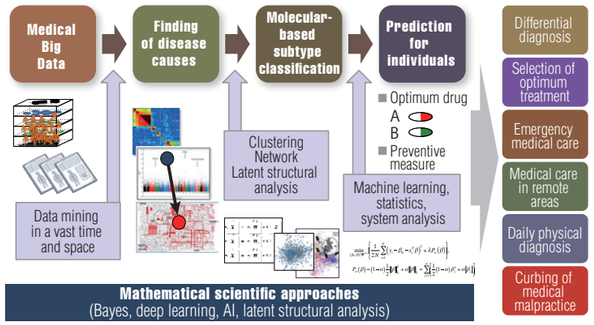
Professor
Tatsuhiko Tsunoda
Department of Medical Science Mathematics
Medical Research Institute

At the Medical Research Institute, to promote personalized medical treatment and preemptive medicine, Prof. T. Tsunoda is searching for causes of disease and new biomarkers based on the integrative analysis of clinical information and other biodata derived from genomic and other omic profiles. His specialty is mathematics-based genomic medicine and biomedical science. One of the methods he applies in his research involves the use of AI.

"AI is a convenient way of analyzing medical Big Data. Having collected a vast volume of medical information, you can apply deep learning or other methodologies to train the AI. It is especially good at quickly drawing inferences or making predictions from data analysis. For example, we can expect AI-based analysis to be a useful adjunct to medical treatment by helping us discriminate between subtypes of diseases based on various symptoms, medical histories or physical findings, or by using genetic data to select drugs with fewer side-effects."

Practical examples of everyday AI application in medicine could include supporting treatment in emergency rooms or in remote areas, or reducing the incidence of medical malpractice due to human error based on the daily monitoring of vital signs.

"TMDU is steadily accumulating medical data on a large scale, and has begun preventive and preemptive medicine at the Center for Personalized Medicine for Healthy Aging. Our aim is to prevent disease at the level of individuals by combining genomic data with information on lifestyle habits to help optimize disease prevention efforts."



Using AI to Analyze Pathology Images

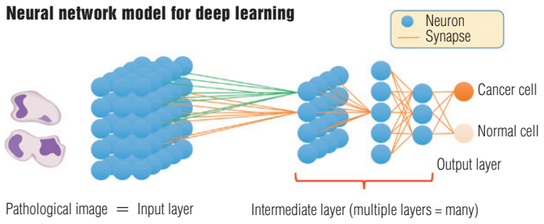
Professor
Shumpei Ishikawa
Department of Genomic Pathology
Medical Research Institute

Clinical pathology is one area expected to benefit from the use of next-generation AI-based technologies. The diagnostic approach in pathology involves direct observation of cells under the microscope to investigate potential malignancy or other characteristics. Some overseas medical institutions have already introduced AI-based pathological diagnosis.

In the Department of Genomic Pathology at the Medical Research Institute, Prof. S. Ishikawa is applying deep learning as an AI-based technology for use in pathological diagnosis. "With earlier machine learning approaches, human input is required to identify unique characteristics. With deep learning, which is being developed mainly for image analysis, the AI can work out these characteristics itself by learning from large quantities of data. In clinical pathology, diagnosis is based on the appearance or form of cells. Unlike a human, who gets tired, the AI can process huge numbers of images to make effective diagnoses."

For example, even skilled pathologists find it hard to diagnose a cancer where a small quantity of tumor cells are present within otherwise healthy tissue. Prof. Ishikawa wants to start with AI supporting diagnosis in such cases, as a way of making sure nothing is overlooked. Based on recent successes in linking accumulated genomic data with pathology images, the team has been researching if data correlation can indicate the need to look for genetic disease.

"The current issue with comprehensive genetic testing for cancer is its high cost. If we could establish strong links between specific disease genes and tissue images, highly cost-effective genomic treatments based on genetic analysis might become feasible at low cost."

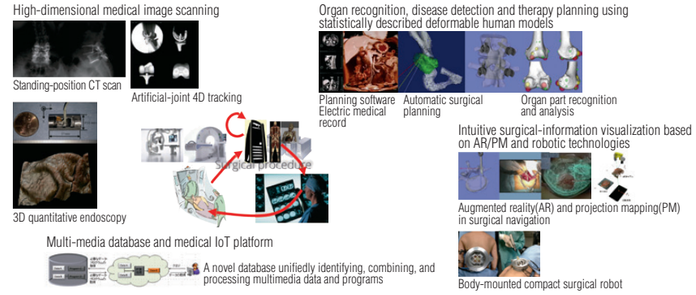


Cutting-Edge Data-Derived Medical Engineering

Professor
Yoshikazu Nakajima
Department of Biomedical Information
Institute of Biomaterials and Bioengineering

At TMDU's Institute of Biomaterials and Bioengineering, Prof. Y. Nakajima is researching the integration and automation of various medical data. His specialty is medical engineering based on the links between computers and medical treatments. One approach is a surgical navigation system driven by diagnostic imaging equipment (such as CT or MRI scanners) and image sensors. With the aim of helping to support safer surgical procedures, the system combines data from preoperative treatment plans with images taken during surgery to guide surgical instruments. Another approach uses deformable human models to establish parameters for the location and size of healthy organs, based on links between these parts and relevant visual, textual or other information. By combining this information with data from patients, it is possible to estimate the probability of disease based on deviation from standard parameters. The data also provide a searchable database of detailed medical knowledge.

"In my research, we combine diagnostic imaging data from CT or MRI scanners and conduct multi-dimensional analysis by applying the inter-data relationships to mathematical models. Entirely new types of analysis are possible with this approach because we can do a top-down analysis of the distribution or create mapping with other data." The institute has specialists in many different fields such as biosensing, device development, materials, pharmacology and software development. Assembling this array of talent promises to unlock new possibilities in next-generation medical engineering.



New Data-Related Personnel Development Program

Specially Appointed Professor
Hiroshi Tanaka
Manager
Medical Data Sciences Office

In April 2017, TMDU embarked on a 5-year "data-related personnel development program" on behalf of the Ministry of Education, Culture, Sports, Science and Technology (MEXT). Under the program, MEXT has set up the Consortium for Data Sciences in Medical Care and Drug Discovery with the twin aims of developing new data science education programs and of organizing international research conferences to exchange information in this area. As the lead institution in the consortium, TMDU is managing the personnel development program and liaising with medical IT enterprises and pharmaceutical companies. The program curriculum is aimed at 30 graduate or postdoctoral students, along with 30 course participants from the companies. The core curriculum comprises lectures and practical classes on medical Big Data and AI-based drug discovery. Besides the pharmaceutical companies involved, the locations for the training program include the Tohoku Medical Megabank Organization and the National Institute for Educational Policy Research.

Prof. Tanaka, the program coordinator and manager of the Medical Data Sciences Office, emphasizes the program's high quality, which includes a stellar lineup of lecturers.

"The data science lectures alone will be extremely valuable. The panel of lecturers includes Jun Tsujii, the head of the Artificial Intelligence Research Center at the National Institute of Advanced Industrial Science and Technology, and Professor Masaru Tomita from the Institute for Advanced Biosciences at Keio University. Participants will also benefit from internships at program-affiliated institutions and receive counseling from TMDU's Career Development Office to support their careers after finishing the program."