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Report

Research Activities in the Department of Medical Engineering

Mitsuo TONOIKE*, Yoshiaki KIMURA, Hiroshi MIYAZAKI, Atsushi SAKURAI, Shimpei KOHRI, Takuto HAYASHI, Hiroyuki YAMASHIRO, Akira IKARASHI, Yoshinori NITTA, Kazuhei KUROSAWA, Yoichi MIZUTANI, Norihiko NAKANO, Yasunori YAMASAKI, Hitomi KIKUCHI, Yuka HATANAKA, and Naoaki ISHINO

Departement of Medical Engineering, Faculty of Health Science, Aino University
(*CA Correspondence Author, Director of Department of Medical Engineering)

The Department of Medical Engineering is dedicated to the research and educational activities to fulfill its mission as educating medical professionals in medical engineering under the diploma policy and curriculum policy, that is, "research and education aiming for fostering professionals competent in comprehensive resolving capacity based upon a wide field of knowledge and vision in clinical engineering, which can be attained by wearing the basic knowledge of medical science and engineering." For this reason, the Faculty of the Department of Medical Engineering is composed of the two areas ; PhDs in engineering-based clinical medicine, and mainly MDs in medical sciences and clinical medicine. To summarize the research activities at the Department of Medical Engineering, the authors will describe the overview of research activities being performed in the Department of Medical Engineering Fields, by dividing into 1) Research in Biomedical Engineering Fields, and 2) Research in Medical Science and Clinical Engineering Fields.

1 Research in Biomedical Engineering Fields

Firstly, in the research field of biomedical engineering (ME), the faculty with wide range of engineering background is involved with the basic research of biological and human organism based on the basic knowledge of mathematics, physics, biology, chemistry, and engineering, and the applied research in bio-engineering and bio-electronics.

Yoshiaki Kimura (professor)[1,2], studies a proximity interaction of proteins as the basis of the life sciences using a microscope or an electron microscope aiming for the elucidation of the structural analysis of functional biological complexes. He is planning a project as the joint research with ultra-high-voltage electron microscope center of Osaka University.

Hiroshi Miyazaki (professor)[3,4], with a grant supported by the Ministry of Education, Science and Technology of Japan, is elucidating the mechanism of a single cell biomechanics and cell nucleus mechanics. He is aiming for the quantitative elucidation of the mechanical field where the cell nucleus is placed by integrating the mechanical properties and three-dimensional morphology of the cells and cell nuclei, and the shape and distribution cytoskeleton and nucleoskeleton.

Atsushi Sakurai (professor) and Shimpei Kohri (lecturer) are involved with the research to apply the knowledge and technology of mechanical engineering and materials engineering in biomedical engineering and biological material.

Sakurai[5, 6] has constructed a dynamic model emulating the movement of artificial substance flow inside the blood vessels and inside of the trachea of the lung in order to study the self-oscillation of the compounds inside the elastic tubes and the mechanism of wave propagation. By comparison of experimental data and the value estimated from the theory, he is building a dynamic model of blood simulated fluid.

Kohri[7, 8] has been studying the deformability of the short axis tensile of red blood cells in his joint research with Kansai University. He measures the time constant of the Young's modulus and shape recovery of the apparent red blood cells in tensile short axis as deformability evaluation index of red blood cells, and analyzes the data on the basis of the Kelvin model to elucidate the recovering process to its original state.

Although Mitsuo Tonoike (professor), Takuto Hayashi (lecturer), and Hiroyuki Yamashiro (assistant professor) are from different academic background, they and now integrated into the common research sharing the advantage of each specialty, which is to reveal the human biological state and brain activity by analyzing the physiological-psychological conditions of humans using various non-invasive experimental techniques. They have been developing the indicators that represent objectively the impact on various biometric and brain imaging measurement method.

Tonoike[9, 10] has been developing a technology to apply these technologies to elucidate the effects of the human five senses to brain function which can be applied to brain-machine-interface (BMI) and brain-computer-interface (BCI). He is especially interested in the research to apply smell stimuli modulating emotion, stress, and cognitive function using magnetoencephalogram (MEG) and functional magnetic resonance imaging (fMRI).

Takuto Hayashi[11, 12], with the background of clinical engineer, has studied the physiological, and psychological indicator for the stress of a healthy person under acute and chronic stress state by measuring electroencephalogram (EEG), magnetoencephalogram (MEG), and electrocardiogram (ECG) as well as cortisol level and IL-6 level in saliva.

Hiroyuki Yamashiro[13, 14] is currently doing research on texture perception without visual attention or visual awareness using brain imaging including functional magnetic resonance imaging (fMRI), supported by the grant from the Ministry of Education and Science of Japan. He is investigating the impact of food stimulus, tactile stimulation and the visual stimuli of various textures, such as face stimuli, on behavior and attention of the human beings.

Akira Ikarashi (professor)[15, 16] is now developing the simple screening system of sleep apnea syndrome using the Kinect sensor, supported with a grant from the Ministry of Education and Science of Japan. He has been establishing the Kinect sensor for the depth detecting a non-contact movement of the chest and abdomen and aims to develop new respiratory measurement method. He has been also trying to develop the 3D posture detection, analysis of snoring sound by multi-array microphone, and facial blood flow measurement by RBG camera.

Yoshinori Nitta (lecturer)[17, 18], is analyzing the mathematical model of the physiological phenomena and also the changes in the membrane during the outside circulation therapies, such as cardiopulmonary bypass aiming for the development of simulator system of the external-circulation therapy in which he studies the change in the water balance and dynamics of dialysis membrane during hemodialysis. The goal of his research is to develop a simulator system which is helpful in improving the safety of the patients under the external circulation therapy.

2 Research in Medical and Clinical Engineering Fields

The second field of the research of the Department can be further divided into the following two fields; the basic medical research related to clinical medicine by medical doctors, and the study of specialized issues of clinical engineering encountered by clinical engineers.

As for an example of clinical research by a physician of the Department, Kazuhei Kourosawa (professor)[19, 20] has been carrying out the research of the transportation of glutathione across the mitochondria and kinetics of hydroperoxide degradation by NADP-glutathione system in mitochondria. Glutathione is present at high concentrations in cytosol and mitochondria in every living cells, playing an important role to remove hydroperoxides produced within the cells.

Reduction power in the active cells is usually reserved by NADPH, which works as electron donor, leading to maintain most of the glutathione at its reduced form. Together with high concentration of reduced glutathione, glutathione peroxidase with its high activity makes it possible to scavenge almost all hydroperoxides generated intracellularly instantaneously. Glutathione is synthesized in cytosol, and transported into mitochondria by exchange for phosphate. Small amount of hydroperoxides is easily reduced by the glutathione peroxidase system, but when massive peroxide is loaded, rate-limiting reaction is at the re-reducing step of NADP driven by supply of substrates including oxygen.

Yoichi Mizutani (professor)[21, 22] has been also carrying out the research of the clinical application on early diagnosis of bladder cancer. He is studying the behavior of the mouse which can perceive a little change in the odor of the urine from the cancer patients, to confirm the bladder cancer-specific urine odor from a small amount of urine by behavioral experiments. He is further trying to identify the characteristic component to bladder cancer by component analysis of GC-MS.

Norihiko Nakano (associate professor)[23, 24] is a medical doctor belonging to both the Department of Medical Engineering and Institute of Regeneration and Rehabilitation. Nakano is currently involved with the research on the analysis of nerve regeneration factor in the bone marrow stromal cells supported by the grant from the Ministry of Education and Science of Japan. He studies the effects of cell transplantation or culture supernatant administration of bone marrow stromal cells to the model animal of spinal cord injury. The clinical evaluation of the therapy is under study in collaboration with his colleagues in Kansai Medical College and Kitano Hospital. Using liquid chromatography, he is trying to identify the nerve regeneration factor from the culture supernatant of bone marrow stromal cells with the aim to elucidate the mechanism properties and action mechanism of the factor

As the study of issues related to clinical engineering, Yasunori Yamasaki (associate professor)[25, 26] has conducted research on the clinical problem-solving of the artificial heart-lung system. He is involved with the basic research of the biological invasion mechanism under the artificial heart-lung circulation of experimental animal, verification experiment for the biological invasive reduction, development of artificial circulation device trying to resolve issues such as the delay of the recovery after surgery due to biological invasion of the artificial heart-lung circulation, challenge to serious complications under artificial circulation.

Hitomi Kikuchi (lecturer)[27, 28] studies the fetal heart rate labor diagram (CTG), which is frequently used at the time of delivery in order to assess the status of the fetus. She studies the pattern classification of fetal heart rate (FHR) recommended by the Japanese Society of Obstetrics and Gynecology aiming for the development of CTG automatic identification system.

Yuka Hatanaka (assistant professor)[29, 30], specialized in blood purification therapy, is involved with the research on the driving sound of blood centrifugal pump in percutaneous cardiopulmonary support (PCPS). There are several clinical conditions where blood centrifugal pump is suddenly stopped during use, or the emergency exchange is required due to the abnormal sound from the blood a centrifugal pump. She is trying to establish the criteria for replacement of the blood centrifugal pump by sorting out the abnormality in a variety of patient biological information and the abnormal noise from the apparatus to detect the deterioration and failure of the pumping apparatus.

Naoaki Ishino (assistant professor)[31, 32] studies the development of in vitro anti-thrombotic evaluation apparatus of artificial organs to be used in the circulatory system relying the luminous phenomenon and the ultrasonic Doppler method. He can detect the chemical luminescence of ATP by photomultiplier tube (PMT). Then he tries to detect an obturator by Doppler method after the thrombus has been formed.

Prospects for Future Challenges in Medical Engineering

The staff of the Department is composed of the faculty with the background of engineering and medical science. This feature of the staff characteristics is unique to the Department, not found in other universities or medical schools. In other words, the Department of Medical Engineering in Aino University has significant advantages in the research environment. In the Department, there is ample exchange of information between the field of medicine and

engineering, which can be the advantage of Aino University.

Since the Department is still new, however, the scientific communication in the workplace is not yet enough to pursue the maximum education and research in the field of medical engineering. Even though the exchange of information can be carried on individual basis, the more intimate discussion and communication among the staff is desired in the future.

Under the common research goal more deployment of effective medical engineering research, we expect more exchanges, promotion of joint research, cooperation and collaboration inside and outside of the Department.

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