The University of Electro-Communications

UEC *e*-Bulletin

Updates on research, innovation, and events at UEC:
Unique and Exciting Campus in Tokyo

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- Drag reduction and relaminarization of wall-turbulence by traveling wave control

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JST-ERATO Intelligent Optical Synthesizer (IOS) Project

Optical technology has not been utilized to its full potential, although there is no doubt about its importance for applications in daily life and science and technology. By appropriate control of the unique properties of optical waves with high precision and wide dynamic range opens of the possibilities for innovative applications over a broad range of fields.

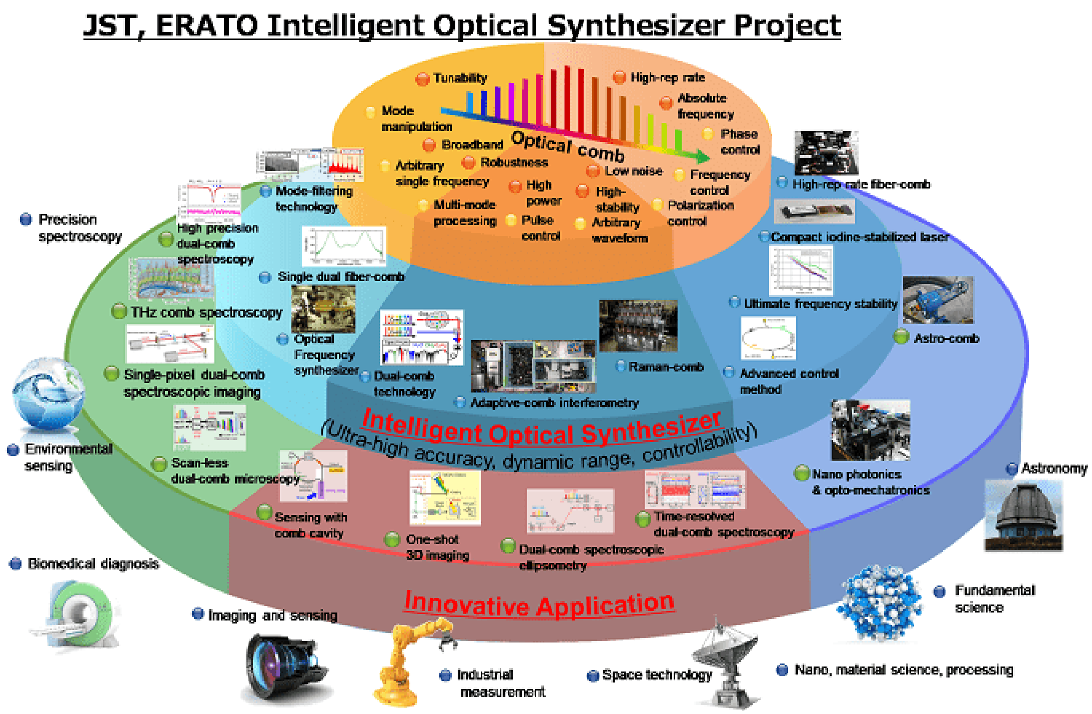
The main goal of the JST-ERATO Intelligent Optical Synthesizer (IOS) Project [1,2] is to develop optical technology for controlling properties of light waves based on advanced laser technology, referred to as "Optical Frequency Combs" (OFCs). Simply started, OFCs is composed of large numbers of equally spaced, optical frequency modes. This discovery was awarded the Nobel prize in physics in 2005 and has been known as the most precise "optical ruler" ever made by human-beings.

However, in spite of the attractive features of OFCs, there is a huge gap between technology available for producing light sources and real-world applications. To bridge the gap, there is high expectation of research on the development of technology to utilize the full properties of OFCs and for basic application technologies utilizing its unique features.

Kaoru Minoshima, the Research Director of the ERATO-IOS project and professor of the UEC, and her project team are developing a diverse range of fundamental technologies for controlling broad aspects of optical waves based on OFCs, such as in time, frequency, space, phase, polarization, coherence, as an "optical synthesizer", which is an analogy of musical instruments known as synthesizers. Moreover, the ERATO-IOS project team are utilizing the controllability of light for broad innovative applications, which are based on original and innovative applications of the full range of properties of OFCs, not only as previously reported precision frequency rulers, but as extremely accurate tools for multi-dimensional information conversion and control over a wide dynamic range.

The researchers have developed a wide variety of OFC sources exhibiting world-class performances for applications, such as the highest repetition rate low-noise Yb:fiber OFC that was stabilized without additional amplification [3], a fiber laser which emits highly coherent two OFCs ("dual-comb") simultaneously enabling high-precision, broadband and rapid spectroscopy with practical light source [4], and mode-filtering technique for high sensitive spectroscopy that can be applied for real-time environmental and medical sensing [5,6]. The team have also developed new spectroscopy techniques for direct and rapid characterization of the complex properties of a broad range of materials and devices with a wide dynamic range in time, frequency, and space domains [7,8]. An ultrafast three-dimensional imaging method was also developed, which is expected to be applied to rapid sensing of microscopic to large objects without losing its high accuracy [9,10]. The team has also developed a high-accuracy long distance measurement technique with automatic compensation for air turbulence by propagated light itself that is expected to play a major role in industry and big science. Notably, one of the OFCs developed in this project was installed in an astronomical observatory for future application for searching extrasolar planets.

The technologies being developed have opened up new and important applications of light, and there is the potential for many other applications covering a broad range of fields.



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・Researcher Video Profiles: http://www.ru.uec.ac.jp/e-bulletin/researcher-video-profiles/2019/kaoru-minoshima.html

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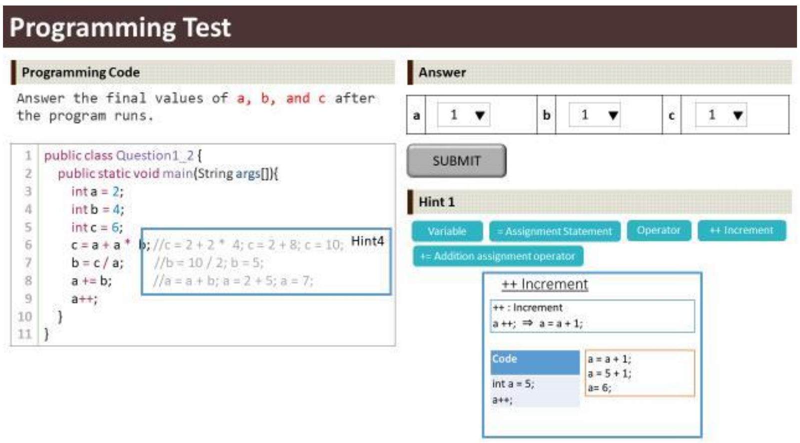
Adaptive learning system using big data based machine learning

Over the past few decades, many studies conducted in the field of learning science have reported that scaffolding plays an important role in human learning. To scaffold a learner efficiently, a teacher should predict how much support a learner must have to complete tasks and then decide the optimal degree of assistance to support the learner's development. Nevertheless, it is difficult to ascertain the optimal degree of assistance for learner development.

In this study, we assumed that optimal scaffolding is based on a probabilistic decision rule: given a teacher's assistance to facilitate the learner development, an optimal probability exists for a learner to solve a task. To ascertain the optimal probability, we developed a scaffolding system that provides adaptive hints to adjust the predictive probability of the learner's successful performance to the previously determined certain value, using a statistical machine learning technology.

Furthermore, using the scaffolding system, we compared learning performances by changing the predictive probability. Our results showed that scaffolding to achieve 0.5 learner success probability provides the best performance. Also experiments demonstrated that a scaffolding system providing 0.5 probability decreases the number of hints (amount of support) automatically as a fading function according to the learner's growth capability.



Intelligent scaffolding system to provide adaptive hints.

The University of Electro-Communications 1-5-1 Chofugaoka, Chofu, Tokyo 182-8585

Reference

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- Researcher Video Profiles: http://www.ru.uec.ac.jp/e-bulletin/researcher-video-profiles/2019/maomi-ueno.html

Drag reduction and relaminarization of wall-turbulence by traveling wave control

Energy saving is important to reduce transportation costs of vehicles as well as their impact on the environment. In this context, because skin-friction drag increases significantly in turbulent flow, it is important to study flow control techniques for turbulent flow.

Turbulent flow is a strongly nonlinear phenomenon having a very complex structure consisting of i.e., vortical and velocity streak structures. Therefore, it is difficult to decrease the skin-friction drag in turbulent flow.

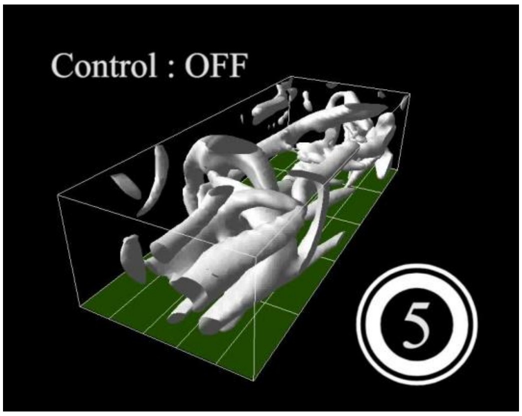
In a recent report, Hiroya Mamori and colleagues showed traveling wave control of turbulent flow. The traveling wave control is the blowing and suction from the wall in the form of the traveling waves.

They performed direct numerical simulations of the fully developed turbulent channel flow controlled by traveling wave-like blowing and suction. Furthermore, the effect of control parameters on the drag reduction effect was also extensively investigated.

They found that the turbulent flow becomes the laminar flow with positive energy saving when waves travel in the same direction as the base flow, and they reveal the parameter range of relaminarization phenomenon.

Traveling wave control is very simple, and attractive for control effects. Notably, the control is expected to be extended in wider situations, including separation flow control.

Note
This research was conducted at the Tokyo University of Agriculture and Technology. Hiroya Mamori is currently at the University of Electro-Communications, Tokyo.



AL-1 is running to calculate the square root of 3

Reference

- Authors: Hiroya Mamori, Kaoru Iwamoto, and Akira Murata
- Title of original paper: Effect of the parameters of traveling waves created by blowing and suction on the relaminarization phenomena in fully developed turbulent channel flow
- Journal, volume, pages and year: *Physics of Fluids* 26, 015101 (2014).
- Digital Object Identifier (DOI): 10.1063/1.4851256
- Affiliations: (Current) Department of Mechanical and Intelligent Systems Engineering, The University of Electro-Communications
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- Researcher Video Profiles: http://www.ru.uec.ac.jp/e-bulletin/researcher-video-profiles/2019/hiroya-mamori.html

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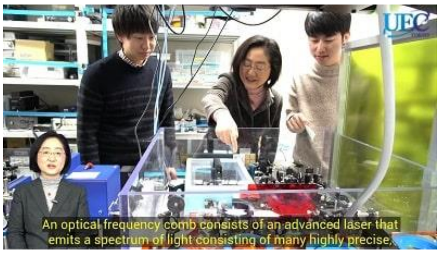
UEC e-Bulletin Vol.21, March 2019

Kaoru Minoshima, Professor, Department of Engineering Science, Graduate School of Informatics and Engineering

Optical frequency comb technology



Kaoru Minoshima is focused on expanding the applications of optical technology that is limited at the moment. For example, one reason is that at several 100 terahertz (THz) the frequency of light is too high to directly control and manipulate signals using conventional technology.

Minoshima and colleagues are developing advanced optical source known as "optical frequency comb technology". "Based on this technology, my group is developing "optical synthesizers", which are tools that enable versatile control and manipulation of light analogous to musical instruments," says Minoshima".

An optical frequency comb consists of an advanced laser that emits a spectrum of light consisting of many highly precise, equally spaced optical frequency modes. It is also an extremely accurately controlled ultrafast pulsed laser that emits optical pulses with a very short time duration. Therefore, optical frequency comb technology provides very accurate controllability of multi-dimensional information, for example, in time, space, and frequency domains. Minoshima's group is conducting research to realize "optical synthesizer technology" for applications in a wide range of fields in science and technology.

Specific examples of technology being studied include high-sensitivity spectroscopic sensing for environmental, medical, and astronomical spectroscopy applications; new spectroscopy technique for direct, rapid, high-precision, and high-sensitive characterization of multiple properties of materials; high-accuracy long distance measurement techniques with compensation for air turbulence; and ultrafast three-dimensional shaped measurement techniques that simultaneously realize both broad range and high accuracy. It is important to note that these applications cannot be realized by conventional technology.

"We will continue this research to fully utilize the properties of light with the aim of cultivating innovative applications in over a broad range of science and technology fields, such as environment, biomedical, astronomy and space technology."

Further information

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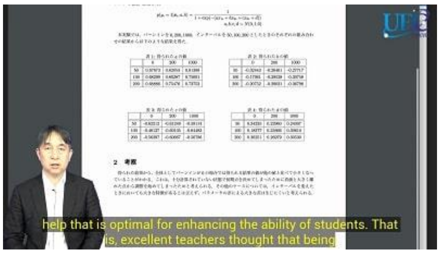
Research Highlight:

http://www.ru.uec.ac.jp/e-bulletin/research-highlights/2019/jst-erato-intelligent-optical-synthesizer-ios-project.html

Maomi Ueno, Professor at the Graduate School of Informatics and Engineering

Adaptive learning system using big data based machine learning



Maomi Ueno is conducting research on machine learning, artificial intelligence, big data analysis, centering on Bayesian statistics. I this video he describes his group's research on education system with artificial intelligence using machine learning. The system adaptively supports the system according to the student's abilities and is called adaptive learning.

Recently, tablet PCs have been introduced in schools in vast quantities and are spreading explosively. Conventional adaptive learning of artificial intelligence estimates where students stall and teaches them carefully from there. However, many educational experts say, "students should not be taught too much or too little about the difficult parts of education. Let students think for themselves and give adaptive and minimum support as possible for education to be effective". So, what is the best support? That is the main question in this study.

Ueno thought that when students were solving problems, whether it would be actually possible to give the minimum level of support. And, excellent teachers were predicting the probability that students can achieve their task with their support. In addition, he hypothesized that there might be the probability of giving a correct answer that is optimal for enhancing the ability of students. That is, excellent teachers thought that being able to predict the performance of learners before supporting them was an important requirement.

This is a very difficult task, but in fact, machine learning in artificial intelligence is good at predicting the performance from students based on their previous performance at learning new tasks. Therefore, Ueno proposed a framework that selects and presents support/hints so that the probability for a correct answer becomes 0.5 using machine learning to analyze the past learning history of students, before supporting students.

Specifically, Ueno and his colleagues have developed an adaptive learning system that evaluates the ability of students based on tasks to write computer programs. When students make a mistake, the system gives hints to so that the probability of students giving the correct answer to a problem is 0.5.

First, after a lesson on programming with a simple example of a program, we conducted a post test on students by implementing the conventional system and the new proposed method with various prediction probabilities and compared the learning effects. As a result, they found that it is effective for learning to assign a hint so that the probability of correct answer is 0.5 just by setting a slightly difficult task it at first. Surprisingly, it turned out that teaching methods that teach everything from scratch as in the past had the least learning effect and the students were only able to do the tasks that were taught. They cannot solve questions that were slightly different from the initial task.

In the system that gives hints so that the correct answer probability becomes 0.5, as the student's ability increases in the learning process, Ueno found that the amount of support necessary gradually decreases, that is, the number of hints decreases gradually, and even if assistance was necessary initially, the students gradually become independent.

Ueno found that this process is the most effective learning process. Currently, we are developing new systems for mathematics and other subjects such as English. "In addition, although I am using a mathematical model that can be applied only to closed problems, I would like to develop a mathematical model that can be applied to open problems such as writing essays and other needs of evaluators."

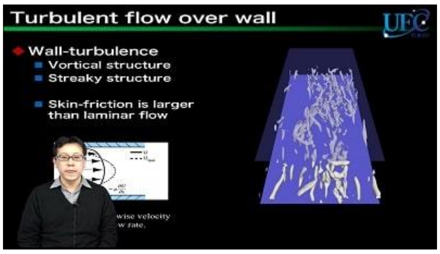
Further information

Maomi Ueno
Professor at the Graduate School of Informatics and Engineering, The University of Electro-Communications.

Research Highlight:
http://www.ru.uec.ac.jp/e-bulletin/research-highlights/2019/adaptive-learning-system-using-big-data-based-machine-learning.html

Hiroya Mamori, Associate Professor, Department of Mechanical and Intelligent Systems Engineering

Simulating the control of turbulent flow



Hiroya Mamori is studying the control of turbulent flow by using numerical simulation. Recently, the energy saving is very important because it is needed to decrease the transport cost and the environmental impact. In fluid mechanics, flow control to reduce drag is important.

"We are studying flow control technique to decrease the skin-friction drag in turbulent flow by using computer simulation," says Mamori. "Especially, we are focusing on the traveling wave-like control."

The traveling wave control means that the wave is imposed on the wall in the turbulent flow. When the wave travels in the streamwise direction, then not only the skin-friction drag reduction, but also relaminarization phenomenon is obtained. In that case, 70% of the drag reduction is obtained with positive energy saving. This control is very attractive, and Mamori and his colleagues are trying to extend this control in wider situations.

On the other hand, integration of fluid mechanics and informative engineering is also hot topic nowadays. In Mamori's laboratory, they are studying new turbulent flow control techniques by using neural network, for example. "We hope that it becomes new control techniques in near future."

Further information

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Research Highlight:
http://www.ru.uec.ac.jp/e-bulletin/research-highlights/2019/drag-reduction-and-relaminarization-of-wall-turbulence-by-traveling-wave-control.html

Improved catalytic processes for the synthesis of phenol

Researchers at the University of Electro-communications, Tokyo report a single-site catalytic platform with high selectivity for the single-step synthesis of phenol in a paper appeared in *ACS catalysis*.

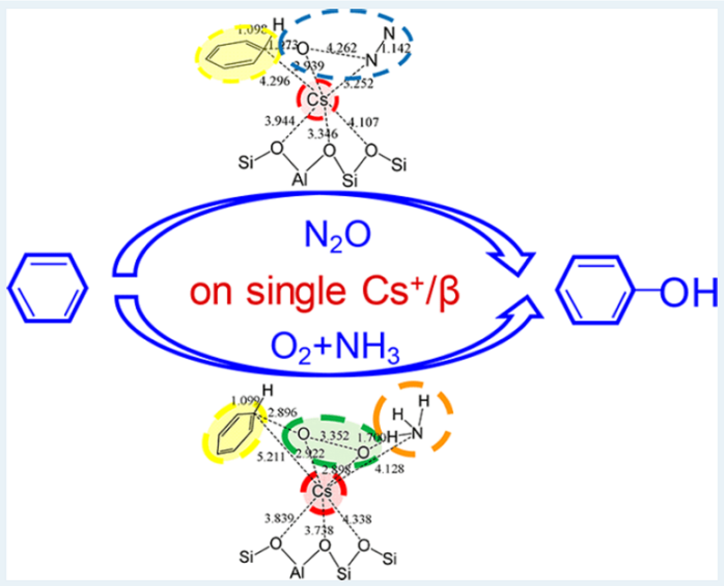
The cumene process is an energy-intensive industrial three-step process (one of the steps is explosive) used to produce phenol (C_6H_5OH), a chemical used as precursor for many industrially important materials, including polymers, drugs and herbicides. It would be highly desirable to find an efficient and less environmentally harmful way to produce phenol, and the best option would be to synthesize it directly starting from benzene, O_2 and N_2O in a single-step catalytic process. Ideally, this would be a gas-phase flow reaction on a solid catalyst, which would make the reaction efficient and result in reduced resource consumption and easy-to-separate products.

Yasuhiro Iwasawa and colleagues from the University of Electro-communications, Tokyo, reported the selective oxidation of benzene to phenol using large alkali metals as active sites incorporated in zeolite pores. There results defy conventional wisdom on catalytic processes, whereby alkali and alkaline metal ions cannot activate benzene, O_2 and N_2O when they absorb separately. The reactions, which were characterized using a combination of synchrotron techniques, display very high conversion and selectivity, in particular for Rb and Cs ions adsorbed on a type of zeolite called β-zeolite.

Two reaction paths were studied: in the first, benzene reacts with N_2O, in the second, with O_2 in the presence of NH_3. Density functional theory calculations were used to understand the mechanism underlying both catalytic reactions. In the first case, the reaction starts with the adsorption of benzene and N_2O; in the next step, the O-N bond in N_2O dissociates, a O-C bond forms on benzene and the H atom attached to the C atom moves to the O, so that phenol is formed and N2 desorbs. In the second reaction, which has a performance less striking than the first, benzene, O_2 and NH_3 co-adsorb; the dissociation of O_2 is activated by NH_3 and, as in the previous case, an O-C bond is formed on benzene, and the H atom on the C atom migrates to the O atom, forming phenol. Because the reaction happens on a single ion site, a large reaction platform is needed, which explains why Cs and Rb, which both have large diameters, work better than other alkali and alkaline metal ions. The regulation of their confinement and local coordination structure by the β-zeolite pore structure also plays an important role.

The authors optimized the catalyst fabrication and reaction conditions, modifying the metal precursors, sources of zeolites and reaction temperature to try to achieve a performance good enough to make the process appealing for industrial applications.

Importantly, the activation barriers are sufficiently small that the reactions can proceed at low temperature. As the authors conclude, "the present findings present a new approach for designing efficient selective C−H activation catalysis under mild conditions."



Graphical abstract from the paper

In this study, we assumed that optimal scaffolding is based on a probabilistic decision rule: given a teacher's assistance to facilitate the learner development, an optimal probability exists for a learner to solve a task. To ascertain the optimal probability, we developed a scaffolding system that provides adaptive hints to adjust the predictive probability of the learner's successful performance to the previously determined certain value, using a statistical machine learning technology.

Furthermore, using the scaffolding system, we compared learning performances by changing the predictive probability. Our results showed that scaffolding to achieve 0.5 learner success probability provides the best performance. Also experiments demonstrated that a scaffolding system providing 0.5 probability decreases the number of hints (amount of support) automatically as a fading function according to the learner's growth capability.

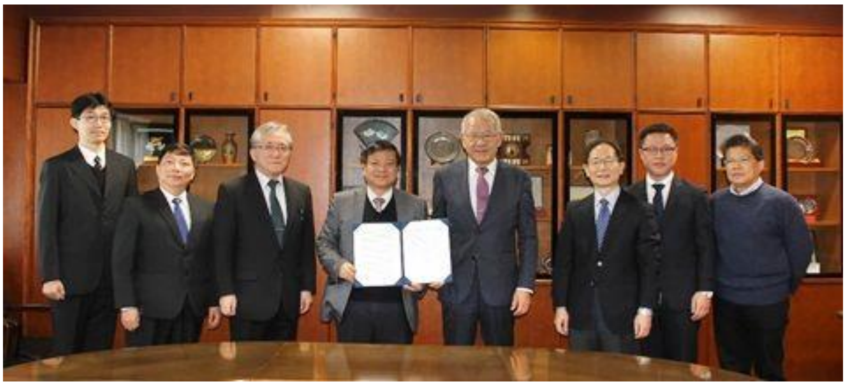
- Authors: Shilpi Ghosh, Shankha S. Acharyya, Takuma Kaneko, Kotaro Higashi, Yusuke Yoshida, Takehiko Sasaki, and Yasuhiro Iwasawa
- Title of original paper: Confined Single Alkali Metal Ion Platform in a Zeolite Pore for Concerted Benzene C−H Activation to Phenol Catalysis
- Journal, volume, pages and year: *ACS Catal*. **8**, 11979−11986 (2018)
- Digital Object Identifier (DOI): DOI: 10.1021/acscatal.8b03002
- Affiliations: Innovation Research Center for Fuel Cells, The University of Electro-Communications, Chofu, Tokyo 182-8585, Japan, The University of Electro-Communications.

Delegation of NHTD visits UEC

On January 11, 2019, Dr. Nguyen Van Kinh, the Director of National Hospital of Tropical Diseases (NHTD), and Dr. Nguyen Vu Trung, the Vice Director of NHTD, visited the University of Electro-Communications (UEC).

President Fukuda, Dr. Nakano, the Members of the Board of Directors of UEC, and other professors of UEC welcomed Dr. Nguyen Van Kinh and Dr. Nguyen Vu Trung, and they had active discussion for the collaboration between the two institutions. After the meeting, they visited Laboratory of Prof. Kirimoto and Asst. Prof. Sun in the Department of Mechanical and Intelligent Systems Engineering; and Laboratory of Prof. Ishibashi in the Department of Computer and Network Engineering.

NHTD is one of the top hospitals in Vietnam in clinical education and research of infectious diseases. NHTD and UEC signed cooperation agreement in March, 2018, and have been collaborating actively. Furthermore, NHTD and 3 other institutions in Hanoi, and UEC have set up Global Alliance Laboratory, which can be jointly used by faculties and students of the institutions, in December, 2018.



Group Photo

UEC signs Agreement of Double Degree Program with IPN

On 11 December, 2018, the University of Electro-Communications (UEC) signed an Agreement of Double Degree Program with the Instituto Politécnico Nacional (IPN), Mexico. The two institutes have been partner institutions since 1998 and engaging in active collaboration, especially student exchanges.

The purpose of this agreement is to develop a Double Degree Program between PhD Program in Communications and Electronics of IPN and the PhD Program of UEC, in order to train leaders and experts with global perspective through the collaboration between the two institutes.

The University of Electro-Communications (UEC) in Tokyo

is a small, luminous university at the forefront of pure and applied sciences, engineering, and technology research. Its roots go back to the Technical Institute for Wireless Commutations, which was established in 1918 by the Wireless Association to train so-called wireless engineers in maritime communications in response to the Titanic disaster in 1912. In 1949, the UEC was established as a national university by the Japanese Ministry of Education, and moved in 1957 from Meguro to its current Chofu campus Tokyo.

With approximately 4,000 students and 350 faculty, UEC is regarded as a small university, but with particular expertise in wireless communications, laser science, robotics, informatics, and material science, to name just a few areas of research.

The UEC was selected for the Ministry of Education, Culture, Sports, Science and Technology (MEXT) Program for Promoting the Enhancement of Research Universities as a result of its strengths in three main areas: optics and photonics research, where we are number one for the number of joint publications with foreign researchers; wireless communications, which reflects our roots; and materials-based research, particularly on fuel cells.

International Public Relations
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