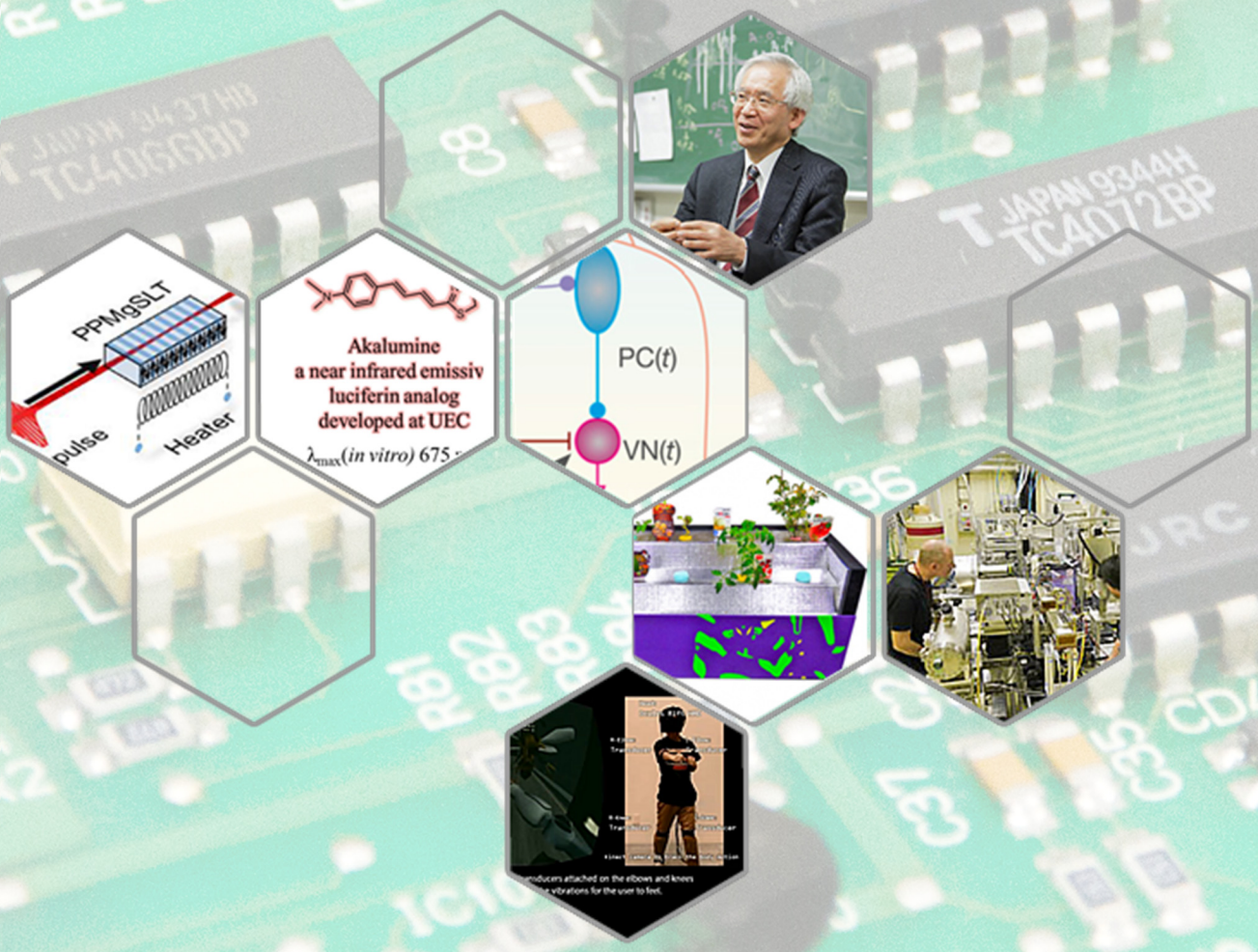
The University of Electro-Communications

UEC e-Bulletin

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

Vol.5, March 2015



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Feature

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Fuel cells in the spotlight

In-situ, dynamic X-ray absorption fine structure (XAFS) spectroscopy to demystify the behavior of catalysts in fuel cells

Professor Yasuhiro Iwasawa, head, Innovation Research Center for Fuel Cells

In autumn 2014 Toyota Motor Corporation announced the start of the commercial sales of the 'Toyota Mirai'--the world's first commercially available hydrogen fuel-cell vehicle.

"This announcement was the culmination of decades of research on polymer electrolyte fuel cells (PEFCs)," says Professor Yasuhiro Iwasawa, head of the Innovation Research Center for Fuel Cells at the University of Electro-Communications, Tokyo. "Toyota's hydrogen fuel cell vehicle is one example of the potential applications of fuels cells for generating 'green energy'. However, there is still a lot of fundamental research required in order to benefit from the ultimate potential of PEFCs. In particular, our understanding of the chemical reactions governing the generation of electricity from fuel cells is still incomplete. Specifically, the atomic structure, reactions mechanisms, and degradation mechanisms of fuel cell catalysts are still a black box."

Real-time XAFS experiment for polymer electrolyte fuel cells at UEC/NEDO beamline BL36XU @SPring-8

With this background, Iwasawa and colleagues have constructed a unique 80 meter beamline at the SPring-8 synchrotron facility at Harima Science Park City, Hyogo Prefecture, Japan, as part of an approximately US$26 million national NEDO project to develop X-ray absorption fine structure (XAFS) spectroscopy to probe the behavior of catalysts in fuel cell.

"Our XAFS beamline enables in-situ and real time measurements with high time and spatial resolution, and importantly, under conditions used for operational fuel cells," explains Iwasawa. "Such XAFS measurements are only possible with our beamline. It is truly unique."

Lab. members near the BL36XU hutches

Notably, the UEC-Tokyo SPring-8 XAFSs beamline (BL36XU) was built to study nanoparticle catalysts in the cathode inside the membrane electrode assembly (MEA) during power generation. The beamline enables time and spatial XAFS measurements with a time resolution of 100 microseconds, spatial resolution of 200 nm, and depth resolution of one micron [1].

Recent highlights of research being conducted by Iwasawa and colleagues includes the direct mapping of the degradation of platinum (Pt) nanoparticle catalysts in PEFCs by nano-XAFS with a beam size of 570 × 540 nm2 or 228 × 225 nm2 [2]. More specifically, the researchers, succeeded in the two-dimensional mapping of Pt species in electrode catalyst membranes and in the identification of dissolved species and preferential sites using the nano- XAFS with the highest spatial resolution reported to-date. XAFS showed the selective oxidation and dissolution of the Pt nanoparticles as four-coordinate Pt2+-O4 in the 2-3 μm region around the boundary between the cathode catalyst layer and the electrolyte membrane and around micro-crack boundaries.


at Iwasawa lab. seminar

"These findings are expected to enable engineers to design and develop 'experiment based knowledge' electrode catalysts for the next generation of fuel cells for applications including cars and electricity generation systems for homes," says Iwasawa. "We welcome researchers from all over the world to join us in our research with our beamline at SPring-8 on in-situ analysis of PEFCs."

References

[1] O. Sekizawa et al, *J. Phys.: Conf. Ser.* 430, 012020, (2013).
doi:10.1088/1742-6596/430/1/012020
[2] S. Takao, et al, Mapping Platinum Species in Polymer Electrolyte Fuel Cells by Spatially Resolved XAFS Techniques, *Angew. Chem. Int. Ed.*, 53, 14110 (2014).
DOI: 10.1002/anie.201408845

Further information

Iwasawa Laboratory: http://www.iwasawalab.pc.uec.ac.jp/index_eng.html
Innovation Research Center for Fuel Cells at the University of Electro-Communications, Tokyo: http://www.icfc.uec.ac.jp/index_eng.html

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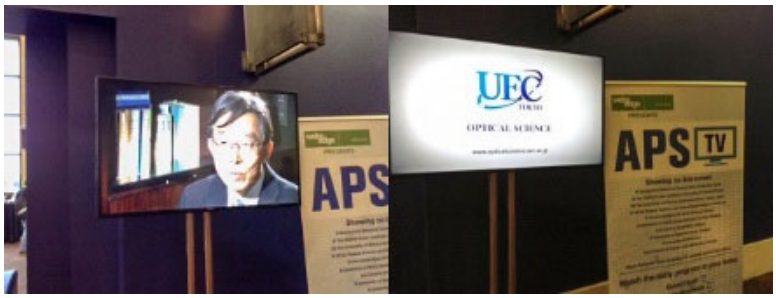
UEC Optical Science group featured in APS TV video

UEC Tokyo researchers invited to appear on APS TV at the American Physical Society Meeting, March 2015 San Antonio.

Scientists at UEC Tokyo are internationally acknowledged for their research in optical science. Examples of excellence in optics include cold atoms, optical combs, high intensity lasers, and notably, the ceramic laser was invented by researchers at UEC.

So it was not a surprise when Websedge, London, invited the Optical Science group at UEC to be featured in a video to broadcast at the American Physical Society Meeting, March 2015, San Antonio. This invitation is timely, considering that 2015 is the International Year of Light.

Professor Shinichi Watanabe, Department of Engineering Science, UEC, was in charge of preparations for the video shoot in January 2015. The resulting video was shown at the APS conference and several hotels associated with the conference, as shown in the photographs provided by Prof. FUSEYA Yuki, Division of General Education, UEC.



The full version of the video can be seen at the website below.

Optimal Optical Science, The University of Electro-Communications, Tokyo:
http://www.websedge.com/videos/aps_tv_2015/#/optimal_optical_science

YouTube: https://www.youtube.com/playlist?list=PLGVe6BxyFHNVCEd-X1a_mv0pVRuI4Z43z

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Quantum optics: Understanding spectral properties of broadband biphotons

Advances in quantum optical technologies require scientists to control and exploit the properties of so-called biphotons. Biphotons occur when two photons become 'quantum-entangled' - spatially separate entities whose individual quantum states must be described with reference to each other. Biphotons of different wavelenths can be created, with broadband biphotons particularly useful for quantum optics.

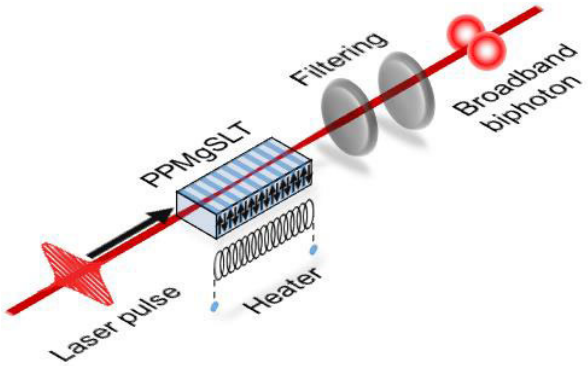
Now, Nandan Bisht and Ryosuke Shimizu at the University of Electro-Communications in Tokyo, Japan, have successfully generated broadband biphotons using a strong laser pulse beam shone through a so-called PPMgSLT crystal, and examined their associated spectral properties and interference patterns.

This method of generating biphotons is known as spontaneous parametric down-conversion (SPDC). Most photons from the laser pass straight through the crystal. Occasionally random pairs of photons appear within two defined cone-shaped trajectories - one cone comprising horizontally-polarized photons, the other carrying vertically-polarized photons. At the point where the 'cones' meet, the photon pair trajectories exist simultaneously and the photons become entangled, creating 'biphotons'. This technique allows scientists to create highly specific optical fields.

Previous attempts at generating broadband biphotons with thin crystals led to a loss of brightness in the resulting optical field. Using the PPMgSLT crystal, Bisht and Shimizu successfully generated broadband biphotons with a spectral width of over 40 nanometers. Their tests showed that the spectral properties of biphotons appeared to be mainly determined by the spectral properties of the chosen laser pulse. The team hope that properties of biphotons could be deliberately controlled to improve optical fields for future quantum information and communication technologies.

Reference

1. Bisht, N.S. & Shimizu, R. Spectral properties of broadband biphotons generated from PPMgSLT under a type-II phase-matching condition. *Journal of the Optical Society of America* **32** (4) (2015)



Researchers at the University of Electro-Communications have successfully generated broadband biphotons and examined their spectral properties. Their insights may help create controllable optical fields for use in quantum information and communication technologies.

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Motor memory: the long and short of it

Recent studies of long-term motor memory have pointed out the involvement of synaptic plasticity at multiple sites in the cerebellum, but the physiological mechanism remains unclear. Now results from a collaboration of researchers at the University of Electro-Communications and the RIKEN Brain Science Institute in Japan, and the University of California, San Diego, in the US, successfully integrated the multiple plasticity mechanisms to explain the formation of long-term motor memory using simulations based on a mathematical model.

Until recently motor memory was widely considered the result of 'long-term depression' - a state of reduced efficacy following a stimulus - in the synapses at output neurons in the cerebellum called Purkinje cells. Yamazaki and colleagues developed a model for the optokinetic response (OKR) in eye movement that incorporated long-term potentiation - a state of increased efficacy following a stimulus - in the synapses at vestibular nuclear neurons. Thus, the model incorporates two distinct plasticity sites that function synergistically.

The model accurately reproduced experimental results. It showed that an hour's training resulted in a short-term increase of OKR gain, for which long-term depression at the Purkinje cells are responsible. Repetition of this training once a day gradually increased the level of OKR gain after training rather than during it, for which long-term potentiation at the vestibular nucleus neurons are responsible.

"It thus appears as if short-term memory formed in the Purkinje cells during 1-hour training is transferred to the vestibular nuclear neuron after training to consolidate as long-term memory," concluded the researchers. Their model also reproduced characteristics of the OKR behaviour observed in genetically manipulated mice.

Reference
Yamazaki T, Nagao S, Lennon W and Tanaka S Modeling memory consolidation during posttraining periods in cerebellovestibular learning PNAS 112(11): 3541-3546 (2015)
doi: 10.1073/pnas.1413798112

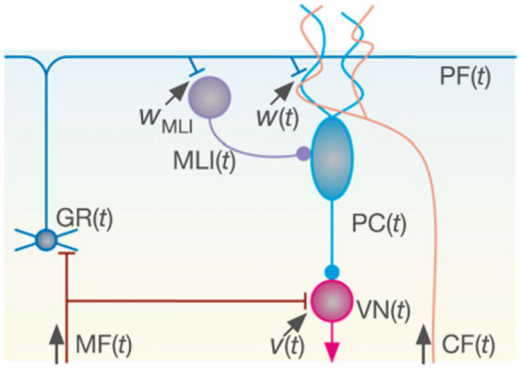

Diagram of the cerebellar network. The elements depicted are MF: mossy fibre; GR: granule cells; MLI: molecular layer interneurons; PC: Purkinje cell; VN: vestibular nuclear neuron; and CF: climbing fibre. The weights w and v at PF-PC and MF-VN synapses respectively were modelled to change with time, whereas the weight w_{MLI} at PF-MLI synapses was set to be a constant.

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Human Interface: Virtual robotization for human limbs

Recent advances in computer gaming technology allow for an increasingly immersive gaming experience. Gesture input devices, for example, synchronise a player's actions with the character on the screen. Entertainment systems now use special haptic displays - these are attached to the player's body to provide so-called 'vibrotactile feedback', synthesizing the feeling of being attacked during combat games, for example.

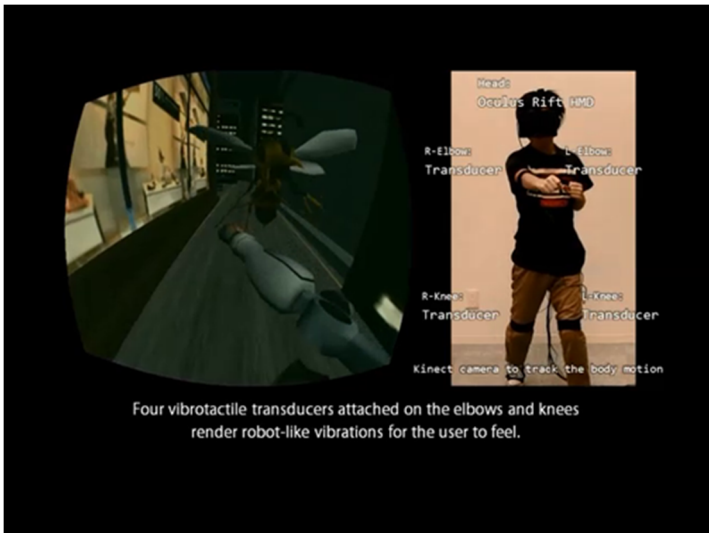
A new virtual reality robotization gaming system called Jointonation, developed by Hiroyuki Kajimoto at the University of Electro-Communications in Tokyo and co-workers, has taken gaming to a new level by allowing the player to discover what it feels like to become a robot. The robotic simulation uses a combination of visual, auditory and tactile sensations to 'transform' the player's arms and legs into metallic limbs.

Vibrotactile feedback makes use of sensory receptors in the skin which respond to mechanical stimuli such as pressure and distortion. By triggering a certain response to sensations, it is possible to 'fool' the brain into thinking these sensations are real. Kajimoto and his team synchronized the limb movements of an on-screen robot with the player's three-dimensional limb movements. They then used modelled vibration data recorded from the arm joint of an industrial robot, combined with robotic sound recordings, to simulate the feeling of robotic limbs via vibrators attached to the player's elbows and knees.

Trials of Jointonation proved a great success, with the combination of visual, auditory and haptic sensations providing very effective 'robot-like' feelings in players' limbs.

Reference

1. Kurihara, Y., Takei, S., Nakai, Y., Hachisu, T., Kuchenbecker, K.J. & Kajimoto, H. Haptic robotization of the human body by data-driven vibrotactile feedback. *Entertainment Computing* **10** (2014)



Researchers at the University of Electro-Communications have successfully developed a robotization game system called Jointonation capable of simulating what it is like to have robotic limbs. The system could pave the way for a new, immersive computer gaming environment.

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Brain Science Inspired Life Support Research Center, UEC

Brain Science Inspired Life Support Research Center was established in May 2013 as an interdisciplinary research institute with the mission of helping people to live peacefully in an aged society. "The BLSC was set up based on UEC's philosophy of 'comprehensive communication sciences', says Shigeru Tanaka, Specially Appointed Professor Office of Comprehensive Communication Sciences Initiatives. "Our Center has specialists from a wide range research areas including brain science, informatics, robotics, and optics. Research staff include Yoichi Miyawaki, a tenure track associate professor who is conducting experiments on sensory information processing of the brain using functional MRI and EEG measurement systems."

A major goal of the BLSC is to devise 'innovative technologies' to assist the elderly with cognitive and physical difficulties by facilitating students from a diverse range of backgrounds with the appropriate interdisciplinary skills for the challenges ahead.

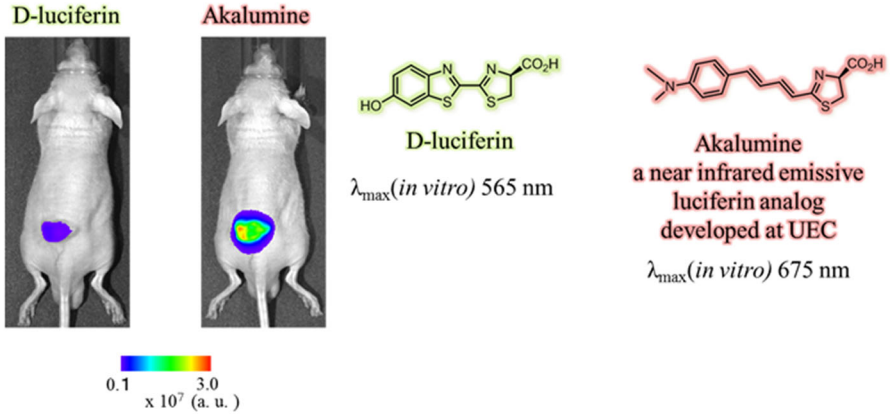
Highlights of programs at the BLSC

Discussion on how to improve artificial hands created by a three-dimensional printer at Professor Yokoi's lab

The BLSC was established to nurturing experts capable of initiating interdisciplinary solutions to some daunting issues on health and welfare in an aged society. With this goal in mind, the 'hands on lecture course' is one of the flagship projects being pursued at the BLSC. "This course is aimed at nurturing human resources to tackle the issues of our superaged society to improve the quality of life," says Haruki Niwa, Specially Appointed Professor at the BLSC. "I am working with colleagues including another Specially Appointed Professor Yukio Yamada and Dr Soichiro Morishita on running this course for graduate school students. One of the most challenging experiments for students is solving of an inverse problem, in which students determine the position of a bioluminescent light source placed in a phantom, a model of animal body. The bioluminescent light is made by firefly luciferase and a rationally designed probes, which is my specialty." The students learn about the functions of human organs such as brain, ears and muscles with lectures and experiments designed by UEC specialists in optics (optical probes, optical imaging technology, and multidimensional image analysis to elucidate the plasticity, self-recovery, and regeneration of function by the brain); in-vivo brain functions (measurement of the response of individual cells under external stimuli, brain imaging related to motor functions, and brain machine interface (BMI) to control and monitor the brain; measurements of motor functions of the brain to develop technology to control and rehabilitate brain functions. This 'hands on course' is financed by MEXT as part of the New Human Resource Development Programs Supporting Super aged Societies with Brain Science Inspired Life Support Innovation (2012-2017).

Further information

1. Brain Science Inspired Life Support Research Center:
http://www.uec.ac.jp/eng/research/researchcenters/blsc.html
2. Shigeru Tanaka Lab: http://tanaka-lab.net/
3. Yoichi Miyawaki Lab: http://www.cns.mi.uec.ac.jp/index.html



Bioluminescence imaging of subcutaneous tumor expressing firefly luciferase after injection of AkaLumine or D-luciferin (equal molar quantity). Akalumine (right) is more effective against imaging of deep site than D-luciferin (left). Photos by Takahiro Kuchimaru and Shinae Kizaka-Kondoh (graduate school of Bioscience and Biotechnology, Tokyo Institute of Technology).

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Developing strategies to counter cyber-attacks on industrial infrastructure

Cyber-attacks, computer viruses, and hacking are terms synonymous with unapproved access of computer systems managed by banks and national security organizations. However, such 'cyberattacks' have recently been directed at factories and manufacturing plants, power stations, and even water purification facilities.

Professor Seiichi Shin, Control System Program Department of Mechanical Engineering and Intelligent Systems

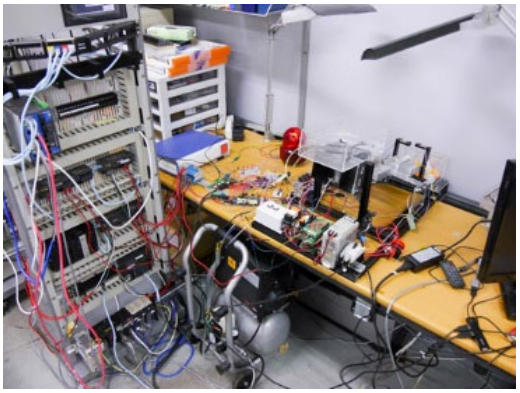
"The proliferation of factory automation based on computer networks connected to the internet has led to a dramatic increase in malicious cyber-attacks on such facilities," says Professor Seiichi Shin, at Department of Mechanical Engineering and Intelligent Systems, University of Electro-Communications, Tokyo. "A critical change in the pattern of cyberattacks was seen with the Stuxnet computer worm attack on a nuclear power plant in 2010. This incident and the massive damage caused by the Great Tohoku Earthquake on 11 March 2011 led to the Japanese Government to establishment the 'Control System Security Center' (CSSC) in 2012. I am the president of the CSSC and UEC is the base for our activities."

Associate Professor Kenji Sawada, Control System Program
Info-Powered Energy System Research Center

Notably, in contrast to governmental cyber security groups in the USA and EU that are managed by national defense organizations, the majority of the 30 members of the CSSC are industrialists from Japan's top-tier private companies. "The members share information without compromising know-how and intellectual property rights," says Shin. "The key in our strategy is to mix our knowledge of information and control systems. This is crucial because attacks on manufacturing plants use the information networks to disrupt production processes. So the CSSC has experts from both technology sectors. "

Kenji Sawada, associate professor at the Info-Powered Energy System Research Center, at UEC Tokyo, is a member of the Shin Group, and is responsible for developing models for countering cyberattacks on critical manufacturing facilities of factories. "Our models are based on risk assessment analysis," says Sawada. "Recently I worked with graduate school student Mr Tsubasa Sakaki on the construction of an actual model to simulate a cyberattack on the production line of a factory."
The model separates heavy (golf balls) and light (table tennis balls) balls on a conveyer belt and simulates a simple defective discriminator. In the simulation, a virus takes control of actuators and creates havoc with the sorting process. A potentially hazardous situation is detected by comparing the model behavior with the actual behavior and averted by removing control from the remote controller (connected to the internet via Windows software) to a local 'micon' based controller that is not connected to the internet. Such the strategy is named as model-based fallback control.

"Monitoring and preventing cyberattacks in industrial facilities is an important aspect of the increasingly interconnected world," says Shin. "Ordinary households are also vulnerable. So called 'smart meters' for monitoring power consumption and security systems are linked to the internet. Our research at UEC and the Control System Security Center is also aimed at mitigating attacks on such systems for the peace of mind of residents of Japan."



Prototype fallback control system with simple defective discriminator.

Mr. Sasaki checks the control logic.

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Seiichi Shin, A status of Control System Security in Japan, The 10th Asian Control Conference 2015, May 31th – June 3rd, 2015.

Kenji Sawada, Tsubasa Sasaki, Seiichi Shin, Shu Hosokawa, A Fallback Control Study of Networked Control Systems for Cybersecurity, The 10th Asian Control Conference 2015, May 31th – June 3rd, 2015.

Websites: http://www.shinlab.mi.uec.ac.jp/

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High tech hydroponics: Fusing information technology with fifteen century approach to agriculture

Professor Akashi Satoh, Department of Communication Engineering and Informatics, Graduate School of Informatics and Engineering, University of Electro-Communications, Tokyo.

Reports on 'hydroponics'--growing plants in aqueous media without soil--can be traced back to the early 1600s. Research shows that plants with their roots in liquid media are able to absorb nutrients more efficiently than those planted in soil. So careful control of the pH and other nutritional aspects of the liquids into which the roots are 'dipped' enables the growth of a wide variety of plants without relying on the weather and even in mega-cities such as Tokyo.

Now, Professor Akashi Satoh, at the Graduate School of Informatics and Engineering, UEC, Tokyo, is using his expertise in the development of high-performance VLSI circuits to give a high tech flavor to the hydroponics.

"The Japanese market for indoor plant factories is estimated to be about 150 billion Yen in 2025," explains Satoh. "The share of indoor plant factories relying on totally artificial light will be approximately 44.3billion Yen. Some major reasons for the increasing interest in hydroponics is that the growth of plants is not affected by the weather and it is possible to carefully control of the quality and safety of the final products, including producing low potassium plants for people suffering from certain illnesses."

Satoh is collaborating with industrial partners to not only grow plants such as strawberries and tomatoes by hydroponics, but to do so on the roofs of skyscrapers in Tokyo. "We want to use hydroponics for capturing carbon dioxide to contribute to efforts to reduce greenhouse gases," says Satoh. "This project will require mixing expertise in engineering with that of agriculture. I am confident that we will be able to succeed in achieving our goals. "

Further information
Home page: http://satoh.cs.uec.ac.jp/en/index.html

Prototypes of hydroponic machine: Sunlight type (left) and artificial light type (right).

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Letter from Alumni

Shakeel Ahmed, Assistant Professor at Department of Electrical Engineering, Pakistan Institute of Engineering and Applied Sciences (PIEAS), Islamabad, Pakistan.

After spending almost four years of my life in Japan, from April 26, 2011 to March 03, 2015, I feel like Japan is my second home. I was selected by the embassy of Japan in Pakistan for Ministry of Education, Culture, Sports, Science and Technology (MEXT) Research Scholarships 2011. Before coming to Japan I was working as a Lecturer in Department of Electrical Engineering, PIEAS, Islamabad, Pakistan.

Dr. Shakeel Ahmed, assistant professor at Department of Electrical Engineering, Pakistan Institute of Engineering and Applied Sciences (PIEAS), Islamabad, Pakistan.

In Japan, I did research on Acoustic Noise Cancellation. During my stay in Japan I have attended international conferences to present my research work. The research work at the University of Electro-Communications (UEC) resulted in two journal publications one published in the journal of IEEE Transactions on Audio Speech and Language Processing and second published in Journal of IET. All this happened because of the friendly research environment in Prof. Zhang Lab. I will definitely miss the time that I spent with my Lab mates from Prof. Wataru Mitsuhashi Lab., Prof. Zhang Lab, and Prof. Yoshikazu Washizawa Lab.

Now that I have graduated from Prof. Zhang Lab, Department of Communication Engineering and Informatics, UEC, as a PhD student, I have re-joined the Department of Electrical Engineering, PIEAS, Islamabad Pakistan. Now I am a member of Signal Processing research group at PIEAS. I am hopeful that I will use the research skills that I developed at UEC for the research in the area of signal processing at my home institution in Pakistan.

The UEC is really a unique and exciting campus. I am thankful to UEC staff and the faculty members for their valuable support and help that made my stay in Japan one of the best period of my life. I will definitely try my best to have some platform to build a research collaboration between UEC and my home institution in Pakistan. I will conclude with the following few words. My love for UEC and for Japan will remain forever and I wish that I could visit Japan again and again for research collaboration and to meet my friends and teachers.

The University of Electro-Communications (UEC) in Tokyo

is a small, luminous university at the forefront of 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.

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