The University of Electro-Communications

UEC e-Bulletin

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

Vol.22, June 2019

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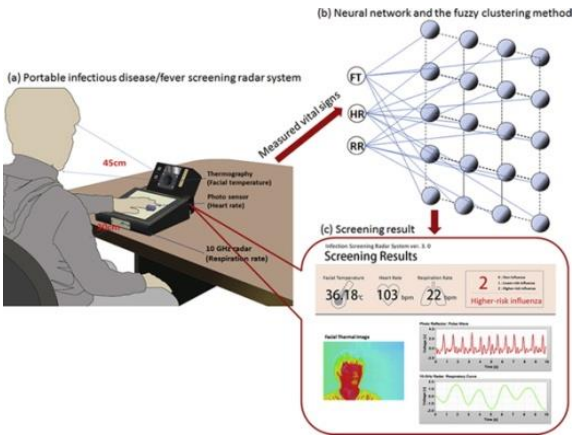
Multiple Sensor Fusion Technology for Non-contact Measurement of Vital Signs and its Clinical Applications

There is increasing interest in technology for non-contact measurement of human vital signs (heart rate, respiration, and body temperature), which are important for understanding the state of a person's health. New biological measurement sensors have been developed as well as reports on methods for measuring respiration or heartbeat using pressure sensors, microwave radar, RGB camera, and thermography. This technology has wide-ranging applications. Guanghao Sun's group is developing clinical applications for monitoring elderly people, identification of sleep apnea, detection of patients who may carry infectious diseases, and noncontact measurement of stress levels [1-2].

Infection screening system based on multiple vital-signs for preventing pandemic diseases

The outbreak of infectious diseases such as swine flu (H1N1) and avian flu (H5N1) are a threat to global health. To prevent and control the spread of infectious diseases, many international airport quarantine areas have adopted fever-based screening using infrared thermography to identify potentially infected individuals. Unfortunately, some studies indicate that fever-based screening at early-stages of infectious diseases is limited due to factors that can affect thermographic measurements, such as antifebrile intake, alcohol consumption, and ambient temperatures.

Guanghao Sun has proposed an infection screening system that can rapidly and accurately perform medical inspections. As a result of being infected, not only body temperature but also heart and respiration rates increase. Sun's system automatically detects infected individuals within 15 seconds by a discriminant function using measured vital signs. Heart and respiration rates are determined using a 24-GHz microwave radar by noncontact way, and facial skin temperature is monitored by a thermographic camera. By using these three parameters, the detection accuracy of the system improved to 88% in a case control study [1]. This is notably higher compared to the conventional screening methods using only thermography.



An infection screening system based on multiple vital-signs for prevention of pandemic diseases

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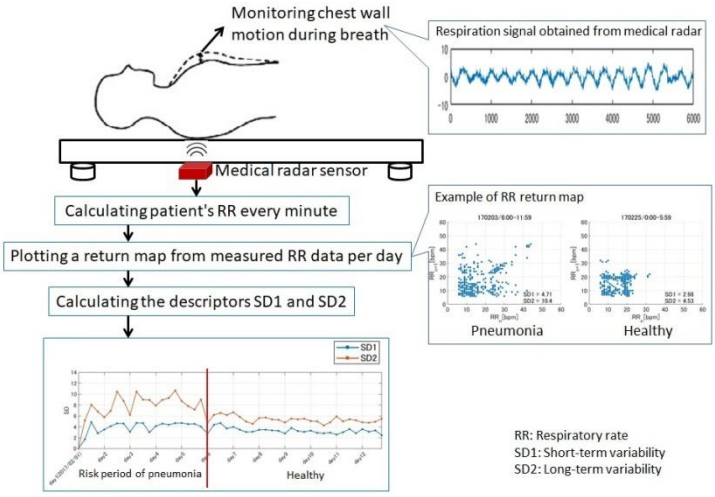
Remote monitoring of respiratory rate using a medical radar system for the early detection of pneumonia in elderly bedridden hospitalized patients.

The use of continuous and long‐term monitoring of respiratory rate is vital for predicting pneumonia in symptomatic patients. However, it is often measured manually and discontinuously by counting chest wall movements in routine practice. Sun has developed a point‐of‐care system for the early detection of pneumonia in symptomatic elderly bedridden hospitalized patients on the basis of 24‐hours continuous and noncontact monitoring of respiratory rate using a medical radar sensor [2].

Sun focused on designing a system that would improve hospitalized patient quality of life and reduce medical staff workload. To this end, the system adopts a medical radar sensor for respiration monitoring that featured an extremely low burden on the patient and enabled unobtrusive measurements without the need to attach electrodes to the patient's body. To reduce medical staff workload, a prediction method, that is, return map, was implemented into the system to analyze the time series respiratory rates, thereby extracting the risk period of pneumonia and sending out an alarm. The novelty of the proposed system is that it introduces a new approach to investigating respiration dynamics using a noncontact medical radar sensor for the early prediction of pneumonia that has the potential to serve as a helpful tool for improving patient quality of life and reduce medical staff workload to meet the needs of the aging society.



Twenty-four-hour continuous and remote monitoring of respiratory rate using a medical radar system

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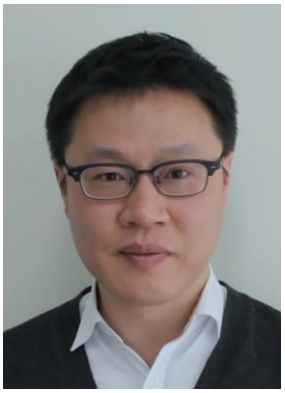
1. Guanghao Sun, Takemi Matsui, Yukiya Hakozaki, Shigeto Abe An infectious disease/fever screening radar system which stratifies higher-risk patients within ten seconds using a neural network and the fuzzy grouping method. *Journal of Infection*, 70(3), 230-236, 2015.

2. Guanghao Sun, Masakazu Okada, Rin Nakamura, Taro Matsuo, Tetsuo Kirimoto, Yukiya Hakozaki, Takemi Matsui Twenty-Four-Hour Continuous and Remote Monitoring of Respiratory Rate Using a Medical Radar System for the Early Detection of Pneumonia in Symptomatic Elderly Bedridden Hospitalized Patients. *Clinical Case Reports*, 7(1), 83-86, 2019.



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

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Frontiers of state of the art precision molecular spectroscopy

The mid-infrared wavelength region is attractive and important for fundamental physics as well as applications such as atmosphere chemistry due to the existence of so-called "molecular fingerprints" that are inherent and strong absorption lines for individual molecules. The detailed analysis of fingerprints reveals the internal structure of molecules and verifies fundamental theories of physics. In the mid-infrared region, especially longer than wavelength of 5 μm, however, the availability of suitable light sources for precise spectroscopy, that is laser source having high power and high frequency stability, are extremely limited. In addition, it is technically challenging to do sensitive spectroscopy in the mid-infrared region because of large noise and small dynamic range of photo detectors.

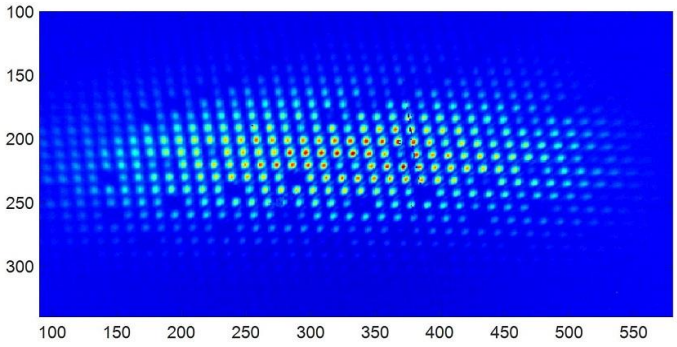

image of spatially separated 10 μm-comb modes. Missing dot is due to absorption of N_2O molecule.

Kana Iwakuni and colleagues have developed a wide range of spectrometers using CW lasers and optical frequency combs [1,2,3,4] and made considerable contributions to molecular science [5,6,7]. Recently, the researchers have developed a direct frequency comb spectrometer at 10 μm using an immersion grating, which is a highly dispersive optical grating to separate each comb mode spatially [4]. The spectrometer can be used to observe temporal development of broadband spectra every 10 μs and the fast acquisition characteristic enables the detection of transient molecules such as NO_3 and Crigee intermediates. Based on these spectroscopic techniques, including optical frequency combs, Kana Iwakuni is aiming to develop novel spectrometers in the mid-infrared region to offer the next advancement for precise spectroscopy when combined with cold molecules.

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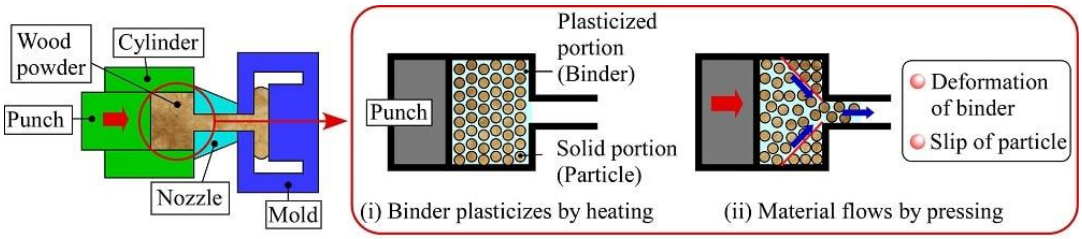
Technology for processing wood powder with natural additives

Biomass materials such as wood are environmentally-friendly alternatives to fossil resources. As an example, wood is typically non-toxic and carbon neutral. Furthermore, wood can be produced in a sustainable manner by appropriate planting and trimming of trees. Therefore, the use of wood resources as industrial materials is an important aspect for realizing a sustainable society.

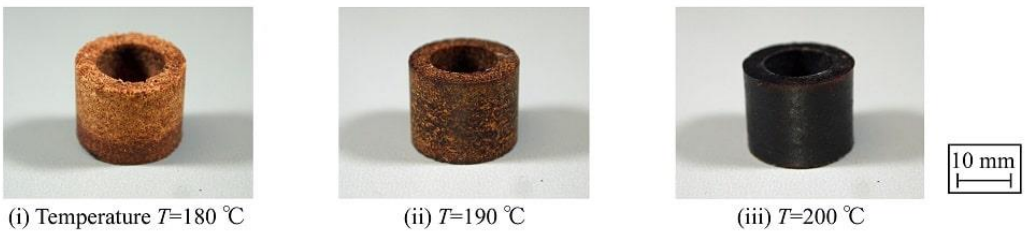
Incorporating wood into industrial applications requires effective processing methods. Wood products are generally shaped by cutting processes because the deformability of wood is inferior to that of metals and plastics. Therefore, much of the original material is turned into waste chips or powder during the cutting process.

Shohei Kajikawa and colleagues at The University of Electro-Communications and Kyoto University developed injection molding of wood powder with sucrose, which is a natural binder, for fabricating products based on natural resources effectively.

In the molding process, the binder plasticizes upon heating and the material, which is composed of the wood particles and the binder, flows due to the deformation of the binder and the slip of the particles. The binder solidifies between the particles upon cooling, and then the material is self-bonded. Fluidity of the material is important for improving moldabiliy, and changes drastically with molding conditions, such as temperature and binder content. Therefore, effects of added sucrose on the moldability of the wood powder were investigated, the molding conditions were optimized by thermal analysis, capillary flow test and injection molding.



(a) Schematic of wood powder molding



(i) Temperature T=180 ℃ (ii) T=190 ℃ (iii) T=200 ℃

(b) Typical appearance of products molded at a binder content of 40 wt%

Injection molding of wood powder with sucrose.

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As a result, the wood powder with the sucrose flowed at temperatures above 180 ºC, although flow was restricted above 220 ºC due to the effect of gases evolved from the sucrose. The minimum sucrose content required for flow was 30 wt% within the temperature range of 180 to 200 ºC. The material was filled in the mold under optimized conditions, and the product with good surface texture was molded at a sucrose content of 30 wt% and 200 ºC.

This proposed method allows the fabrication of products from naturally occurring materials with minimal environmental impact.

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2. Title of original paper: Molding of wood powder with a natural binder.
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5. Department of Mechanical and Intelligent Systems Engineering, The University of Electro-Communications.
6. Kuboki & Kajikawa Lab. website: http://www.mt.mce.uec.ac.jp/

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・Department Website: http://www.mt.mce.uec.ac.jp/
・Researcher Video Profiles: http://www.ru.uec.ac.jp/e-bulletin/researcher-video-profiles/2019/shohei-kajikawa.html

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Guanghao Sun, Assistant Professor, Graduate School of Informatics and Engineering

Multiple Sensor Fusion Technology for Non-contact Measurement of Vital Signs and its Clinical Applications

Guanghao Sun is conducting research on the development of non-contact biometric measurement and technology and their medical applications.

In recent years, research and development of technology for measuring vital signs such as body temperature, heart rate, respiration rate, and blood pressure without touching the human body is attracting attention.

Such non-contact biometric technology has a much lower burden on patients than conventional contact technology, and it can perform continuous monitoring without restraint and unconsciously, for a long time.

Therefore, Sun is using remote sensors such as radar, thermography, CCD cameras, photoelectric pulse wave sensor (PPG), piezoelectric sensor (BCG), electrocardiograph (ECG), and ToF sensor for non-contact measurement of vital signs by developing signal and image processing technology and commercialization and development of medical systems that implement this technology.

For example, microwave radar measures minute movements associated with respiration and heart rate that occur on the surface of the human body and calculates the heart rate and respiration rate. In addition, thermography measures infrared radiation emitted from the body-surface to measure the body temperature without contact.

Utilizing this technology to measure such non-contact vital signs, I am promoting student projects on "infectious disease screening system applied to airport quarantine"; "elderly watching system for home health care"; "sleep evaluation system"; "respiratory function measurement system"; and "evaluation system to measure fluctuations of autonomic nervous function from the heart rate".

Aiming for such practical applications for the social implementation, go from the initial "idea stage", to "system design", "manufacturing", "biosignal processing", "clinical evaluation" and "academia- industry collaboration" in a single process to create medical systems that are useful for people.

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Further information

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Research Highlight:
http://www.ru.uec.ac.jp/e-bulletin/research-highlights/2019/multiple-sensor-fusion-technology-for-non-contact-measurement-of-vital-signs.html

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Shohei Kajikawa, Assistant Professor, Department of Mechanical and Intelligent Systems Engineering

Technology for processing wood powder with natural additives

Shohei Kajikawa working on new processing methods for metals, wood, etc., and the optimization of methods for conventional processing methods.

The specific target of his research is materials processing technology, such as plastic forming, that is used to manufacture parts for all kinds of products ranging from automobiles, home appliances, furniture, housing materials, stationery, etc., that we use daily. If such parts can be manufactured easily and in a short time, it is possible to reduce the cost of products around us as well as reducing the burden on our environmental by improving processing efficiency.

Also, if it is possible to create new shapes that could not be produced before, it would be possible to add new functions to products.

One topic is the development of wood processing technology. Wood is an environmentally friendly resource with low environmental impact, but it is difficult to process efficiently compared to metals and plastics widely used as industrial materials, so the price of wood-made products is high. Also its applications are limited.

The goal is improving the formability of wood by heat treatment and using additives of natural origin, and carry out efficient forming and processing used for metals and plastics.

Products obtained by this method have higher density and harder properties than ordinary wood. I going forward with this research, I think it will be possible to use wood with low environmental impact as a material to replace petroleum-based plastics.

Further information

Shohei Kajikawa
Assistant Professor, Department of Mechanical and Intelligent Systems Engineering, The University of Electro-Communications.

Research Highlight:
http://www.ru.uec.ac.jp/e-bulletin/research-highlights/2019/technology-for-processing-wood-powder-with-natural-additives.html

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Weather monitoring in three dimensions: Rain rate estimates using X-band phased array weather radar network

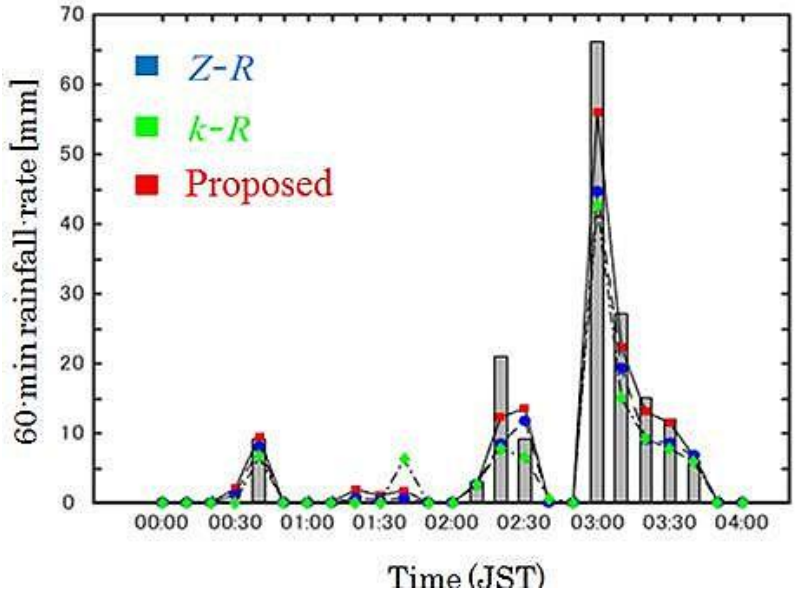
X-band phased-array weather radars (PAWRs) are located at Osaka and Kobe. The PAWR provides a three-dimensional structure of the precipitation within 30 sec.

However, the rain rate estimated by PAWR tends to be underestimated because the rain attenuates the received power.

To resolve this issue Hiroshi Kikuchi, Tomoo Ushio and colleagues at The University of Electro-Communications and Tokyo Metropolitan University show that network observations with two phased array weather radars improves the accuracy of estimating the rain rate within the networked area.

This study proposes a rain rate estimation method by sequentially varying the radar reflectivity factor (Z) and rain rate (R) relationship, the goal being to improve the rain rate estimation accuracy. To calculate the time variation in the Z-R relationship, the rain rate estimated with the existing radar networks and the radar reflectivity observed by the PAWR are used.

The proposed method is significantly better than the other existing two methods at accurately estimating rainfall rate for heavy or violent rain conditions.



Estimation of the rain rate with the existing methods (Z-R, k-R) and proposed method.

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For practical use, it is important to estimate accurate rain rate under heavy or violent rain conditions because storm warnings are issued when the rain rate is over a threshold; the proposed method is particularly effective under conditions of strong rainfall.

Reference

- Author: Hiroshi Kikuchi, Tomoo Ushio, Fumihiko Mizutani, and Masakazu Wada.

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- Journal, volume, pages and year: *IEEE Transactions on Geoscience and Remote Sensing* **56**, 6986 - 6994 (2018).
- Digital Object Identifier (DOI): 10.1109/TGRS.2018.2846818

- Affiliations: Center for Space Science and Radio Engineering (SSRE), The University of Electro Communications, Tokyo.
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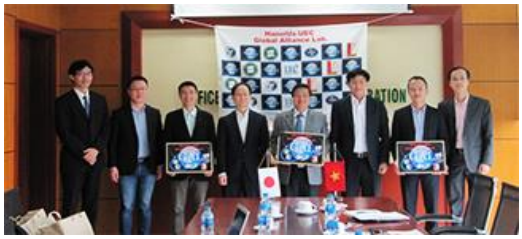
Report：The kickoff meeting and the 5th UEC Seminar in ASEAN, 2019 with partner universities in Hanoi

https://www.uec.ac.jp/eng/news/announcement/2019/20190422_1799.html



HanoiUs-UEC GAL kickoff meeting

As of 8 January, 2019, the University of Electro-Communications (UEC) has signed a Global Alliance Lab: GAL agreement between four sister institutions of the Universities of UEC (Hanoi Us), located in Hanoi Vietnam. The four sister institutions are Le Quy Don Technical University (LQD), VNU University of Engineering and Technology (VNU-UET), National Hospital of Tropical Diseases (NHTD), and Hanoi University of Science and Technology (HUST). GAL recognized "HanoiUs-UEC GAL" as a part of the GAL organization, and a kickoff meeting was held at the executive secretary school of the Hanoi district, LQD, on 27 March 2019. The opening ceremony was held on 29 March during the 5th UEC seminar in ASEAN 2019, as organized by the UEC ASEAN Research and Education Center (UAREC). HanoiUs-UEC GAL is the first of five universities to become part of GAL, and it will promote international collaborative endeavors on research and education.

The 5th UEC Seminar in ASEAN, 2019

At the kickoff meeting and the opening ceremony, Prof. Ky Nam Le, the vice president of LQD, Prof. Bao Son Pham, the vice president of VNU-UET, Prof. Van Kinh Nguyen, the director of NHTD, Prof. Huu Thanh Nguyen, the dean of HUST, Prof. Abe, the vice president of UEC, Prof. Ishibashi, professor of UEC, and other professors of these institutions attended.

At the kickoff meeting, constructive discussions on promoting future collaboration under the name of HanoiUs-UEC GAL was held.

After the vice president of Prof. Koji Abe's speech at the opening ceremony, he explained the organization and introduced examples of inter-organizational collaboration. All members expressed their expectations and aspirations for this collaboration. Approximately 50 welcomed participants attended the 5th UEC Seminar in ASEAN 2019, including those from partner schools in Bangkok, Ho Chi Minh City and Da Nang. In addition to the HanoiUs-UEC GAL opening ceremony mentioned above, information was given on the co-sponsored the ECTI-UEC Workshop on AI and Applications and the UEC Seminar are scheduled for September 2019 in Bangkok.

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Exchanging various examples, ideas, and comments was helpful in promoting future collaborations at this 5th UEC Seminar in ASEAN 2019. The co-sponsorship of the ECTI Workshop on AI and Applications was also fully recognized.

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Announcement of Irago Conference 2019 to be held at UEC on 29 October 2019

Main theme of Irago Conference 2019 Insights into the sustainable development goals: "What About The Earth's Resources? "

Internationally renowned experts will share their insights into the challenges for achieving the goals set out by the UN.

Date: 29 October 2019
Venue: Auditorium, University of Electro-Communications, Tokyo.
http://iragoconference.jp/

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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.

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